COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

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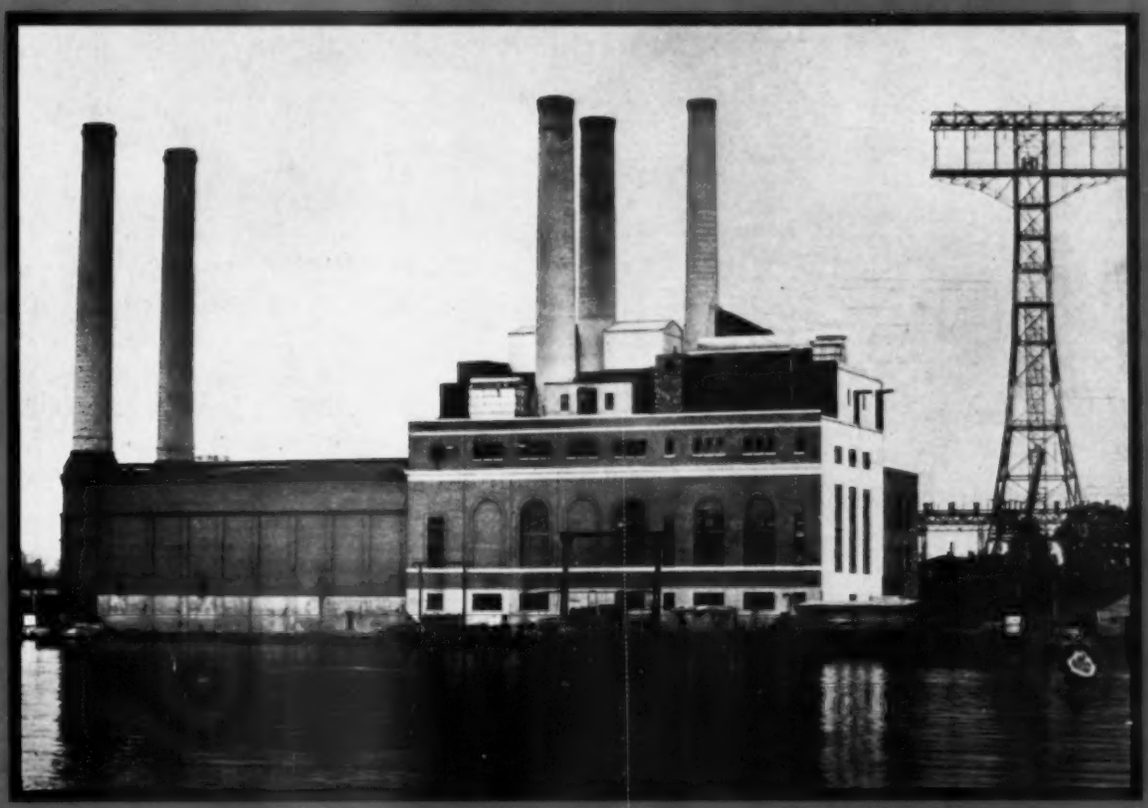


Well-known southern power plant—Reeves Avenue Station of the Virginia Electric & Power Company at Norfolk, Va.

MIDWEST POWER CONFERENCE ▶

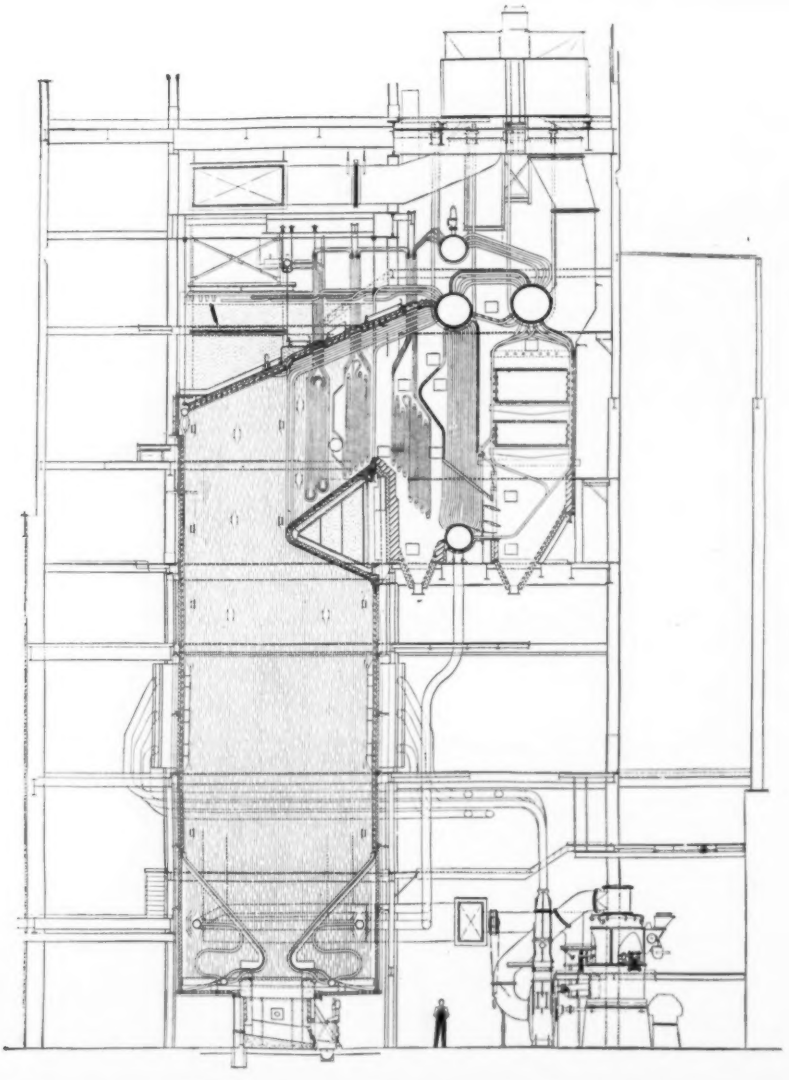
Atomizing vs. Tray-Type Deaerators ▶

Fuel Industry of Japan ▶

Recent C-E Steam Generating Units for Utilities

CLIFFSIDE STATION

DUKE POWER COMPANY



THE C-E Unit, illustrated here, is now in process of fabrication for the Cliffside Station of the Duke Power Company, Cliffside, North Carolina. It is one of two such units now on order.

These units are each designed to produce at maximum output 620,000 lb of steam per hr at 1285 psi and a total temperature of 950 F.

They are pulverized coal fired, using C-E Raymond Bowl Mills and Vertically Adjustable Tangential Burners. The furnaces are completely water cooled with closely spaced plain tubes, basket bottom type. Each boiler is equipped with a 3-stage superheater, Elesco integral economizer in the last pass and a Ljungstrom Air Preheater. Superheat control is by means of Vertically Adjustable Burners and Montaup-type by-pass dampers. B-118

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C-E PRODUCTS INCLUDE ALL TYPES OF BOILERS, FURNACES, PULVERIZED FUEL SYSTEMS AND STOKERS; ALSO SUPERHEATERS, ECONOMIZERS AND AIR HEATERS

COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

VOLUME EIGHTEEN NUMBER TEN

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FOR APRIL 1947

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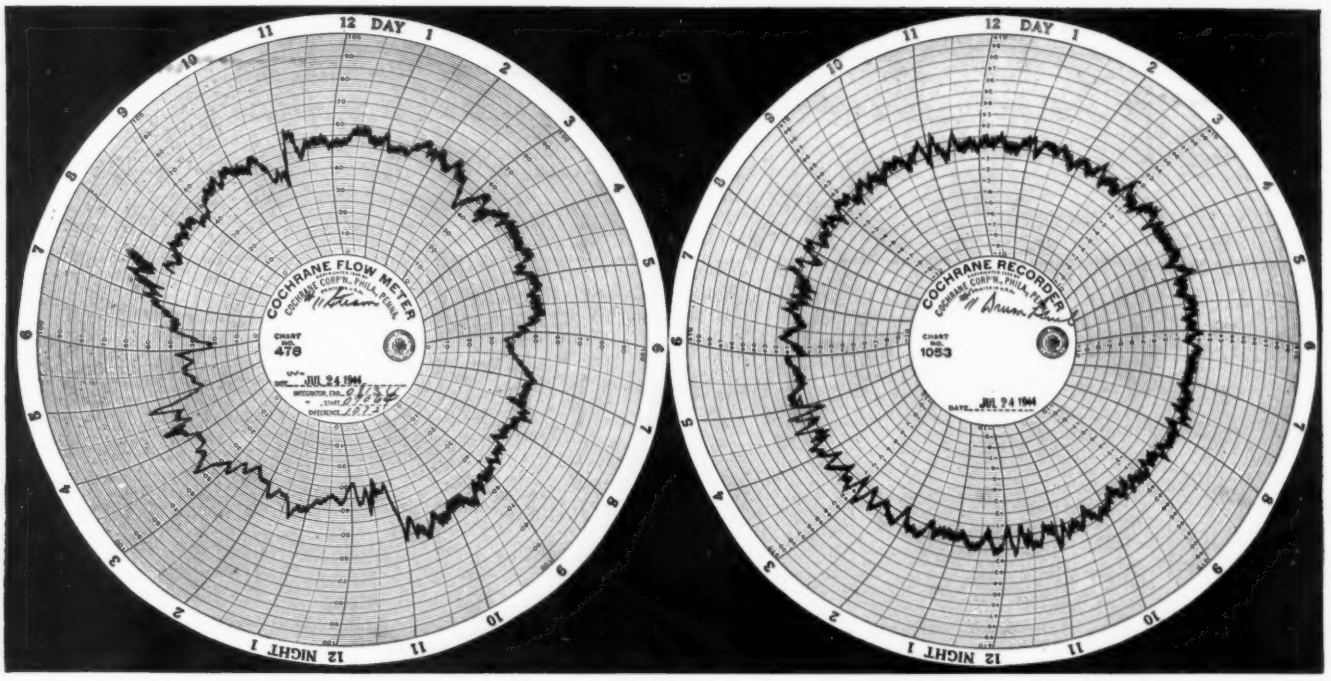

FORGING HAMMERS *Swing Steam* DEMAND 5,000 POUNDS PER HOUR INSTANTANEOUSLY

BOILERS carrying forging loads offer one of the more difficult problems of water level control. Their constant load fluctuations, caused by varying steam demands from hammers and presses, result in abnormal "shrink" and "swell" of fluid within the boiler drum. But COPES Flowmatic Control assures safe, dependable stabilization of the boiler water level, no matter how rapid or wide the load swings.

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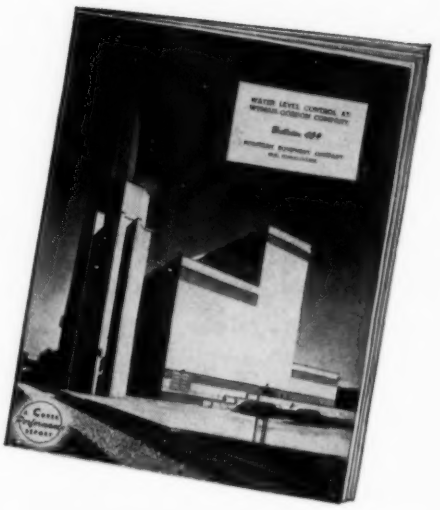

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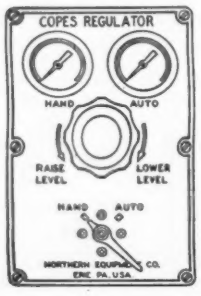

Permits absolute flexibility of installation for COPES Feed Water Regulators of either simple-level-control or two-element Flowmatic type. COPES transfer switch and control panel illustrated provides remote positioning of feed valve from boiler operating board or any other desired point. Air is used as the operating medium. Dependable performance is demonstrated daily in many COPES-equipped high-duty steam-generating stations.

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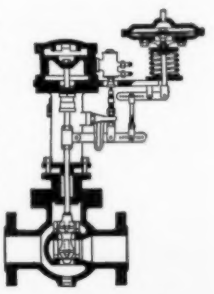


EDITORIAL

Measuring Furnace Performance

For many years combustion rates in boiler furnaces firing fuel in suspension have been expressed in terms of total heat input in Btu per cubic foot of furnace volume. This figure, while useful, does not afford a true basis for comparing boiler furnaces as it fails to take account of the type of firing, furnace wall construction or amount and type of water-cooling surface. Such information is necessary in calculating the temperature of the gas leaving the furnace.

For this calculation one must know the total heat available in the fuel and in the air admitted to the furnace, and the heat absorbed by the effective projected radiant surface. Among the factors affecting this absorption are the type of furnace and wall construction, method of firing, kind of fuel and firing rate.

There are indications that users are beginning to recognize these considerations which will afford a more uniform basis of comparison of furnace performance of different steam generating units.

Five-Day Week Aids Maintenance

Although a large amount of generating capacity is now on order, or in the course of installation in central stations, that actually placed in service since V-J Day has been relatively small. Yet new seasonal highs for both peak demands and total output are being encountered at a time when reserve capacity is critically low, or about eleven per cent average for the entire industry, according to statistics contained in a paper by G. L. Jorgensen at the recent Midwest Power Conference.

Therefore, it is not surprising that some electric utilities which supply large industrial loads are finding the widely increasing adoption of the five-day working week most helpful to their operating departments. The consequent lighter Saturday loads, together with light Sunday loads, affords two consecutive days during which units can be shut down for maintenance. This opportunity is welcomed especially by those plants that now find it necessary to burn inferior coals at high outputs in furnaces poorly adapted to their use—that is, in units designed some years back for high furnace heat releases and high exit gas velocities, with the expectation of burning premium coals. The resulting slagging of gas passages with ash from the inferior coals would likely result in forced outages were there not this opportunity to clean heat-absorbing surfaces. This situation, of course, does not apply to many of the later designs. The two-day light-load period also affords time to service much other equipment in the plants.

But it is not alone utility plants that are benefiting in this respect by the five-day week. Many industrial power plants are similarly taking advantage of such opportunity to service equipment and thereby maintain it in better condition than would be possible with Sunday shutdown only. In some cases it will also avoid the necessity of employing overtime.

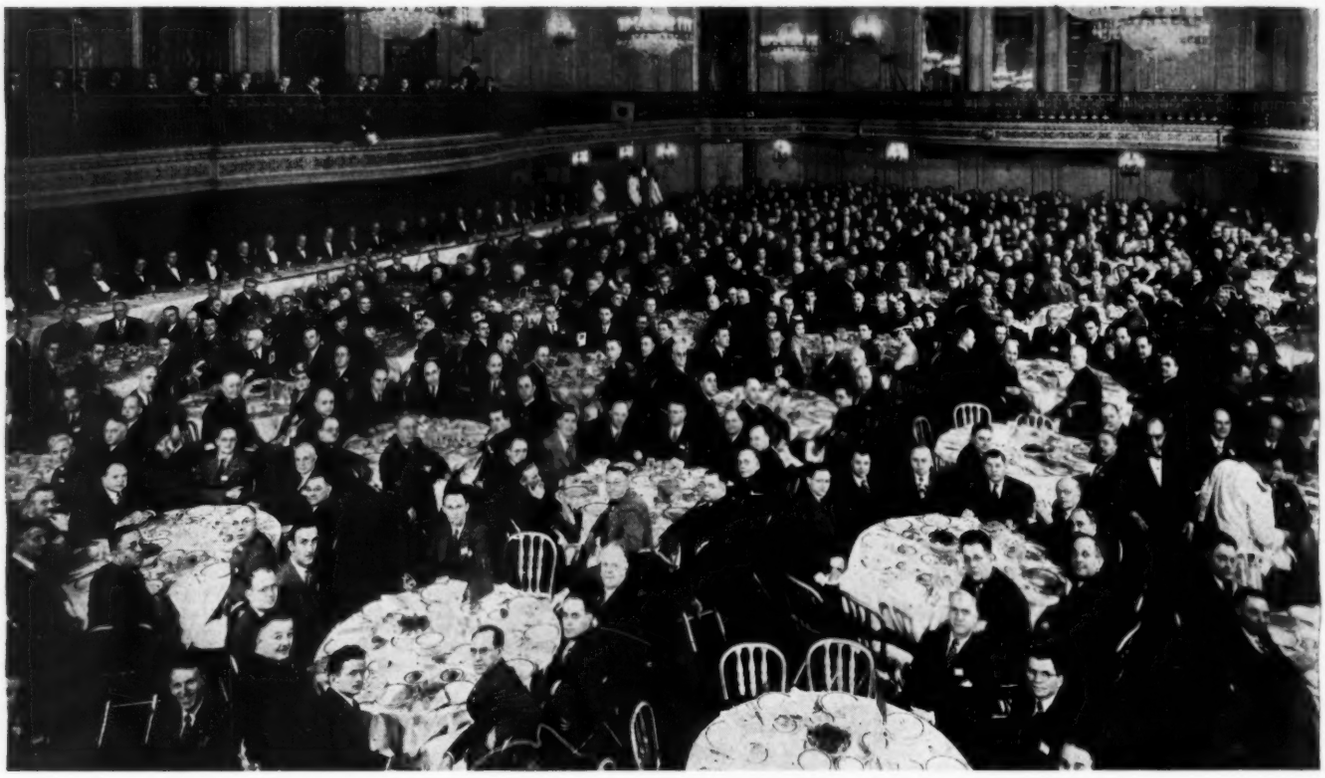
Census Data

The last Census of Manufacturers was taken in 1939. Since then changes wrought by the war and by post-war adjustment have rendered these statistics of very little use to business, and there is urgent need for up-to-date data. In fact, legislation is now pending in Congress which would authorize the necessary appropriation for a current industrial census. It is being actively supported by the U. S. Chamber of Commerce and other business groups, and is likely to receive favorable action. Even the most economy-minded legislators can hardly fail to sense the importance of such a survey to industry.

From time to time COMBUSTION, as well as some other technical publications in the power plant field, has called attention to the desirability of having the Census of Manufacturers include steam-generating equipment, in addition to its customary data on motors and prime movers; for practically all process industries employ large quantities of steam in addition to electric energy for manufacturing operations.

The monthly reports issued by the Department of Commerce on the sale of new boilers, stokers, pulverizers, etc., are helpful in revealing current trends but fail to show anything concerning the number, capacity and age of units already installed. Such information would be of valuable assistance in making studies of potential markets for the various equipment and innumerable accessories involved in the process of steam generation.

The Federal Power Commission has long issued very complete statistics concerning the central station industry and the Bureau of Census has an opportunity to do a comparable job as to industrial power and thereby afford a complete picture of the power situation.



Group attending the "All Engineers" Dinner

MIDWEST POWER CONFERENCE

WITH the usual large attendance and a timely program the annual Midwest Power Conference was held at the Palmer House, Chicago, March 31 through April 2. It included sessions on central station practice, developments in heating and air conditioning, fuels and combustion, power system loads, metallurgy of power plants, feedwater treatment, industrial plants, electric transmission, electronics, diesel engines and gas turbines, in addition to several addresses on non-technical and economic subjects of general concern to the engineer. Space here permits a review only of certain of the technical papers considered of special interest to COMBUSTION readers.

Trends in Electric Power Supply

Speaking at the opening session on Monday morning, **Col. H. S. Bennion,** Managing Director of the Edison Electric Institute, spoke on trends in power supply. He reviewed the growth in post-war demand, installed generating capacity and capacity now on order, the size of units and certain trends in design.

For several months following V-J Day, sales to industrial consumers fell off, reaching a low point in February 1946, although the demand for residential, commercial and rural power increased throughout. At present about 91 per cent of an estimated 38,500,000 occupied dwellings are served by electricity. Beginning in August 1946 the industrial load picked up sharply and has since continued upward, reaching a record peak late in December. The growth is expected to continue through 1947 and 1948 at a rate nearly double the former growth.

Among the factors contributing to this growth in demand are: (1) high industrial activity; (2) widespread one-shift, five-day operation in manufacturing, which lowered the December 1946 load factor to 58.7 per cent compared with 64.2 per cent for December 1944; (3) war-accelerated electrification of industry with electricity cheap compared to increased labor costs; and (4) a high level of aluminum production.

The installed generating capacity contributing to the public supply is approximately 50,300,000 kw and the total, including private industrial plants amounts to about 63,200,000 kw. However, orders for new generating equipment now exceed 13,000,000 kw and it is expected that in the next five or six years 15 to 19 million kilowatts will be installed. Out of 11,300,000 kw reported, about 9,000,000 kw represent steam units, 2,235,000 kw are hydro and 65,000 kw internal-combustion units. Approximately three-fourths of the new hydro capacity is destined for government projects. Of the new steam turbine-generators on order, eleven will be of 75,000 kw, eighteen of 60,000 kw and twelve of 50,000 kw. Of 162 new units only 36 are going into new plants and only one will be a topping unit. About 25 per cent of the new machines will follow the A.I.E.E.-A.S.M.E. standards.

A noticeable trend in station design is the low requirement for attendance labor, the latest stations re-

quiring about one-third, or less, of the operating force employed in older stations of like capacity. Also, outdoor and semi-outdoor stations appear to be on the increase, not only in the southern parts of the country, but in areas where more wintry weather is experienced.

Use of oil as fuel in steam stations increased 108 per cent in 1946 above the pre-war year 1939 and use of natural gas increased 60 per cent.

With reference to construction costs, Colonel Bennion estimated the present average to be about 50 per cent above pre-war figures. In this he saw further opportunity for engineers to improve net results. However, despite increased costs, he predicted that increased sales of electricity would enable the industry to continue for years to bring about the gradual reduction in price of the kilowatt-hour sold, assuming that the value of money is stabilized at approximately where it is now.

Central-Station Combustion Control Problems

C. H. Smoot, Chief Engineer, Development Dept., Republic Flow Meters Company, discussed various methods of combustion control employed in central stations and enumerated some of the disadvantages of certain arrangements. The theoretical objectives were given as accuracy of measurement, stability, maximum possible speed of response and proper coordination of functions while the practical objectives were given as simplicity, reliability, low service cost and adaptability. In addition, the equipment should have good manual control.

In the systems described, the primary quantities to be controlled are the flow of air and fuel for combustion and the flow of gases out of the boiler. The three values of relationship on every boiler which must be maintained constant by the control of the primary quantities are steam pressure, furnace pressure and ratio of fuel flow to air flow. Combustion control can be accomplished by proper connection of these three measurements to the three primary controlled quantities. Also, it can be accomplished by measurements of steam flow and analysis of the flue gas.

In order to fulfill the theoretical and practical objectives, care must be used in deciding which measurement shall control a given controllable quantity and wherever possible the most important quantity should be controlled by the most accurate means.

Several methods were described, one of the simplest being to control the fuel flow from the steam pressure while maintaining the air flow proportional to the fuel flow. Furnace pressure control is usually independent and is set for a constant value to control either the combustion air or the flue gas whichever is not being handled by the air-flow controller. A disadvantage of this method, however, is that by a sequence of events the furnace pressure receives its impulse after a time delay and thus gives poor performance during load swings.

If the air flow is operated to proportion itself to the steam flow, difficulties are often encountered for the following reasons: The steam pressure controller must be stabilized with a fairly slow rate of response in its operation of the fuel flow, due to the heat storage time delay inherent in the boiler. The steam flow-air-flow controller must therefore also be stabilized with a slow rate of response in an attempt to keep this in step with the fuel-flow controller. Hence it will be slow to correct for errors caused by outside influences, such as the change in speed of the fans due to fluctuations in back pressure of turbine-driven fans or disturbances caused by the operation of soot blowers. It should be noted that such a system can be made to operate and many of them are now operating with reasonable success. The point being made here is that more accurate proportioning, especially during load swings, and more rapid response to load changes in general could be obtained if the time delays inherent with such a control hook-up were not present.

Where there are forced- and induced-draft fans, there is a choice as to which should be controlled to maintain the furnace pressure, the other being used to control air flow. Control of the forced-draft air results in speedier response. Here it is desirable to have a venturi section in the forced-draft duct so that all the air for combustion can be measured. This will give a more accurate reading than measurement of gas flow across the boiler; it also eliminates the stack effect of the hot gases and reduces the initial cost. A disadvantage is that the effect of normal fluctuations in the furnace may become magnified.

One simple system, and one of the most widely used, employs a steam-pressure controller arranged to adjust the control point of the fuel-flow controller and the air-flow controller simultaneously. In this case the steam pressure controller is set for a slower rate of response than the fuel-flow controller.

The most satisfactory equipment developed for actuating flows in a boiler system was given as the control value such as used for gas, oil and feedwater control. Others considered in order of importance by the author are the common single or multiple damper, variable-speed devices, variable-speed turbines with governor or throttle valve control, hydraulic couplings and magnetic couplings. Turbine-driven auxiliaries controlled by throttle valves and hydraulic or magnetic couplings are capable of producing a wide range of controllable operation sometimes resulting in a saving in horsepower required, but they do introduce an additional lag in the control system.

Specialized requirements exist where more than one fuel is used especially in varying ratios which are burned with a common air supply, sometimes in the same burner. Another problem is imposed when several pulverizers in one system are made to operate at different rates. Control is accomplished by a device which converts the differential pressures obtained in measuring flow from square functions to linear functions. The sum of these loading impulses is taken on a mechanical adding device and is proportioned to the total air required. The inherent time lag in the control system due to the squaring modulator, totalizing relays and actuating time of the individual controllers will be small compared to those inherent in the large pulverizers and those due to heat storage in the boiler. This system is in successful operation in many large central stations and where conditions require it, the added cost seems to be well justified.

Discussion

W. C. Kramer of State Line Station stated that automatic control was justified by its ability to maintain a constant steam pressure and a steady air-flow steam-flow ratio. It was pointed out, however, that such control was inadequate under conditions of changing load. With fluctuating load it is possible for the air and fuel flows to be continuously out of balance. It was also stated that control by use of CO_2 meter was too slow.

To illustrate his point Mr. Kramer described tests made at State Line Station while burning natural gas to study combustion control. The slowness of steam flow pickup was proved when on increasing the fuel and air flow, an amount sufficient to double the rating, fifteen minutes elapsed before the steam flow equalled this rating.

Continuously recording CO_2 meters were defended in that they gave an indication of the trend of excess air during load changes which could thus serve as a guide in proper air regulation. However, he indicated that even when the air controller is set, there is no means of keeping it there.

Mr. Smoot's closing remarks were directed toward Mr. Kramer when he stated that a control system itself does not provide a means of checkup on its performance. He further stated that CO_2 meters do not record quickly enough for the purpose of making an immediate correction in air flow but do serve as a continuous record of performance. He recommended the use of constant viscosity oil in the dashpots as a means of improving combustion control performance.

Statistics of the Electric Light and Power Industry

These figures presented by **George L. Jorgensen,** of Commonwealth Edison Company, are of particular interest since they reflect the growth of a vast industry that was nonexistent 65 yr ago. They were, in part, as follows:

The total capacity of steam, hydro and internal combustion units on December 31, 1946, was 50,300,000 kw, as compared with 14,000,000 kw in 1920.

Private utility plants account for 81 per cent of the capacity and governmental plants for 19 per cent, the capacity in private plants being 78 per cent steam and 22 per cent hydro—a condition which is reversed in governmental plants with 66 per cent hydro and 34 per cent steam.

Reserve capacity has fluctuated from 50 per cent in 1920, 57 per cent in 1929, 79 per cent in 1934 and 34 per cent in 1945 to 11 per cent in 1946. This last figure called for immediate installation of new capacity and additions for 1947 cover 3,000,000 kw. The total should reach about 60,000,000 kw when present plans materialize.

The average load factor in 1945 was 62.7 per cent with a total output of 222,400,000,000 kwhr and 56 per cent in 1946 with an output of 223,000,000,000 kwhr. Output increased over five fold from 1920 to 1946 and the United States, which has approximately 6 per cent of the world's population, produces 43 per cent of the global output of electricity.

The average number of pounds of coal per kilowatt-hour consumed in fuel-burning utility plants in the United States decreased from 6.7 in 1902 to 1.29 in 1946, whereas some of the most efficient plants produce a kilowatt-hour on well under one pound of coal.

There was a total of over 36 million customers in 1946 of which 86.2 per cent were residential and rural. These accounted for 22.4 per cent of the electricity sold. Small light and power customers represented 17.2 per cent of the sales; large light and power customers 52.2 per cent and other classes 8.2 per cent.

Efficiency of lighting has increased greatly. The old 16-cp carbon filament lamp had an efficiency of 3.5 lumens per watt and the modern fluorescent tubes 49 lumens per watt. Thus for each unit of electricity the customer is now receiving in usable lighting about 14 times as much light as from the earlier carbon-filament lamp. Combining this improved lamp efficiency with the reduction in cost of electricity, the residential customers are now getting about 80 times as much light for each dollar when using fluorescent tubes as they were with the carbon lamps. The average cost per kilowatt-hour for residential customers has decreased from 7.45 cents in 1920 to 3.23 cents in 1946. During this period the use of electricity per residential customer increased 3.9 times and the average cost per kilowatt-hour decreased 57 per cent.

Of the 5,500,000 occupied farms in the United States, 3,400,000 are now using electricity and an additional 700,000 are reached by power lines but are not yet taking service.

As to labor statistics of the electric utility industry, average hourly earnings increased from 67 cents in 1932 to $1.27 in 1946. The total wage earners were 212,000 in 1932, 256,000 in 1941, 200,000 during the war 1944 and now number 246,000.

Without attempting to make forecasts for the electric light and power industry, Mr. Jorgensen observed that during the ten-year period following World War I there was no drop in either customers, kilowatt-hour sales or maximum demand. Before the end of World War II economists predicted that, because of the tremendous increase in industrial loads during the war, a very sizable slump would follow. This has not materialized to date, and should the trend following World War I be realized during the next ten years, the demand would be 2.4 times what it is today, or over 100 million kilowatts.

Inspection for Safety

In a paper on "Safety of Power Plant Equipment" **W. D. Halsey,** Chief Engineer of the Boiler Division, Hartford Steam Boiler Inspection and Insurance Company, contrasted the character and causes of the frequent disastrous accidents of a few decades back with those more prevalent today, and the responsibility of management with regard to proper inspection and maintenance.

Violent boiler and flyweel explosions of the earlier days were usually the result of fundamental defects in design or construction, or the use of inadequate safety devices; but the situation has changed through better knowledge of materials, improved design through adoption of construction codes, improved safety de-

vices, and more general recognition of the value of inspection.

By contrast, recent years have seen a marked increase in accidents caused by carelessness, ignorance, indifference and shortsightedness to a degree that is alarming casualty insurance companies. This applies particularly to disastrous fires, railroad and airplane accidents, although the power plant field has suffered also—usually without widespread publicity.

Mr. Halsey warned against hasty conclusions blaming operators, when it may develop that management has been equally responsible through ignorance, carelessness or indifference in enforcing proper maintenance. Furthermore, while certain trends of the times may be responsible for the indifference and carelessness of operators, there is much evidence to show that operators are not being properly trained. During the decade preceding World War II the training of new operators practically ceased and industry now finds itself without an adequate supply of experienced personnel.

A number of typical examples of accidents attributable to this cause was cited by the speaker.

Continuing, he observed that many plants treat the existence of scale in a boiler as a necessary operating evil, whereas foreign deposits in boilers account for one-fifth the accidents attributable to lack of maintenance in the power plant.

Recent years have seen a rapid increase in the use of automatic controls of power-plant equipment, but such controls require supervision in the form of proper maintenance by trained personnel. Lack of this has resulted in constantly increasing accidents due to failure of automatic devices.

In conclusion, Mr. Halsey stated that many would be amazed if he were to mention some of the large power plants, both industrial and central station, that have suffered disastrous accidents in recent years as a result of ignorance, carelessness, indifference and shortsightedness on the part of both operators and management.

Power for the Paper Industry

This paper was presented by **Robert Krause,** assistant plant manager, Container Corporation of America, Chicago. The importance of power to the paper industry was emphasized by the fact that it represents between 20 and 40 per cent of the cost of the finished paper. That power facilities within the industry are of considerable magnitude is brought out by the last Government power census report which indicated that the total installed horsepower of prime movers in pulp and paper mills was around two and three-quarter million. Of this, approximately 14 per cent was in steam engines and 58 per cent in steam turbines, with the bulk of the remainder in hydro. This generating capacity is able to meet only about two-thirds of the power requirements, the remainder being purchased.

The power plant in a pulp and paper mill must supply four basic products essential to the manufacturing process, namely, air, water, process steam and electric energy. Air which is used in threading the sheet in a high-speed paper machine, in calender stacks and in instruments amounts to one to four cubic feet (free air) per minute per ton of product.

Water must be supplied for boiler makeup which is large, especially if steam is used in direct contact with wood in the digesters, and to the mill for washing and conveying the pulp. This water must be treated for the boilers, and for mill use it must have qualities that will not have a deleterious effect on the paper. Internal treatment of boiler water may be used at low pressure. Most mills, however, use zeolite softening equipment or lime and soda. Up to 200 psi boiler pressure hot lime and soda softening is generally used with separate phosphate treatment. At higher pressures stage heaters may be advisable. Makeup water may vary between 10 and 50 per cent.

The quantity of water used in a mill may vary between 7000 gallons per ton of paper when a closed system is employed and as much as 40,000 gallons per ton with older methods. Efforts to minimize stream pollution have resulted in a substantial reduction in the use of water and subsequent saving of pulp stock and chemicals.

Vast quantities of process steam are required by the digesters in producing pulp and in drying of the paper in the paper machine. In the latter case two and one-half to three and one-half pounds of steam are required per pound of finished paper. Drying is usually accomplished in several pressure sections in the paper machine. The present trend is to use three sections of approximately 40, 25 and 5 psi. Steam may also be employed to treat the water used in dissolving waste paper to a temperature necessary to emulsify waxes contained in this waste.

For plant heating it is common practice to use back-pressure steam at say 60 psi bled from the turbine, from exhaust, or through a reducing valve. In all, it might be expected that the average paperboard mill would require about 14,000 lb of steam per ton of pulp, although in some of the modern mills this figure may be as low as 10,000 lb.

The amount of electric power required per ton of product varies considerably with the plant set-up and the type of product. It will depend on the various types of drive units employed throughout the mill and also on the type of generating equipment. In an average paperboard mill the consumption will run between 225 and 300 kwhr per ton of product.

Regarding fuel, its selection depends on availability and cost. There are no unusual operating practices involving the use of coal, oil or gas. In addition to these fuels a considerable amount of steam is generated from the burning of wastes. These consist of bark, sawdust and other wood waste and the black liquor which is a by-product of pulp making. The latter also contains valuable chemicals which are recovered during the combustion process.

Energy Sources of Tomorrow

In a comprehensive paper **Ralph A. Sherman,** of Battelle Memorial Institute, reviewed the reserves of fuels of different types and the trends in demands by users in various industries and services.

Although our coal reserves are estimated as sufficient for some 1700 yr, our proved reserves of petroleum and natural gas appear to be great enough for only a relatively short period, estimated by some at slightly over

12 yr, in the face of continually increasing demands by various classes of users. However, technological advances have been so rapid that the time is not far distant when the conversion of coal to fluid fuels will be possible at a cost that is not too high for those uses for which fluid fuels are best suited.

Referring to steam generation, Mr. Sherman noted that while pulverized-coal firing has long predominated in large coal-burning plants, both central stations and industrial, the trend is toward equipping such boilers to burn gas or oil as alternate fuels, to take advantage of future availability and costs. For small boilers in the capacity range of 1000 to 10,000 lb of steam per hour oil and gas firing predominates.

Prospects are, however, that no more and possibly less heavy fuel oil will be in competition with coal in the future, despite the expected increased demand for petroleum products; for by catalytic cracking, which has largely displaced thermal cracking, it is possible to supply the requirements of gasoline, kerosene and distillates with yields of fuel oil of not over 10 to 12 per cent of the crude. This is in contrast to the present yield of about 26 per cent.

With the exception of the blast furnace and the foundry cupola, where coke made from coal remains the most suitable fuel for smelting and melting of iron, as well as in the malleable-iron and copper-reverberatory furnace where pulverized coal is the principal fuel, oil and natural gas have become the leading fuels in the metallurgical and ceramic industries.

In the railroad field the supremacy of the steam locomotive has been seriously challenged by the diesel-electric locomotive, despite the fact that the latter costs about twice as much per horsepower and uses a more expensive fuel. However, its efficiency is 26 to 28 per cent as compared with 6 to 8 per cent for the conventional steam locomotive. Sales of the diesel type increased from 40 road locomotives in 1937 to 1571 in 1945, and from 221 switching engines in 1937 to 2375 in 1945. Moreover, as of February 1, 1947, there were 53 steam locomotives on order and 580 of the diesel type.

As to progress in the steam locomotive field, Mr. Sherman stated that a locomotive driven by a steam turbine has shown creditable performance on the Pennsylvania Railroad for the past two years and others of the turbine-electric type are under construction for the Chesapeake & Ohio Railroad. Also, a program for development of a pulverized-coal-fired water-tube locomotive boiler is now under way.

The experimental work on a coal-fired gas turbine that has been carried out by the Locomotive Development Committee of Bituminous Coal Research, Inc., has reached the stage of orders having been placed for two such locomotives. In the opinion of the speaker oil will continue to be preferred as fuel for marine power plants and the gas turbine is likely to find an important place in the marine picture.

Touching upon atomic power, he mentioned that the transformation of one-tenth of one per cent of the mass of one pound of matter into energy releases 11.4 million kilowatt-hours, or the equivalent of 1500 tons of coal or 25,000 gal of fuel oil. However, until experiments now authorized have been carried out and more accurate knowledge is available as to the cost of the materials and of shielding, predictions are of little value.

High-Temperature Steam Piping

Metallurgical considerations in the design of high-temperature steam piping systems were discussed by **J. J. Kanter,** of Crane Company, who stated that new constructions for 900 to 1000 F are now using chromium-molybdenum steels to almost the exclusion of other types, as compared to the pre-war practice of employing carbon-molybdenum for temperatures from 750 to 900 F. However, it has been known for some time that certain types of carbon-molybdenum steels reach the limit of stability at about 850 F, and that graphitization is likely to develop with age at temperatures upward of 900 F, especially in the vicinity of welds.

Subsequent studies have revealed that the susceptibility of carbon-molybdenum steel to graphitization depends to a large extent upon the manner in which the steel has been deoxidized in the steel-making process. It can generally be associated with aluminum killing which is employed to render the steel free from gas holes and surface defects.

That aluminum-killed steels are less stable at high temperatures than straight silicon-killed steel was known for some time before graphitization difficulties arose, creep studies having shown that aluminum-treated and aluminum-silicon-treated steels were generally weaker at high temperature than those killed with silicon alone. While it might therefore seem logical to dispense with aluminum killing, which is feasible in the case of forgings and plate, it is not entirely practical to manufacture seamless pipe and steel pressure castings of acceptable quality unless some aluminum is used. A more desirable course appears to be the adoption of steels that are not susceptible to graphitization.

A small concentration of chromium added to an aluminum-bearing molybdenum steel tends to resist development of graphite formation. Long-time aging tests of such steels up to 1100 F have shown them to be resistant whereas the carbon-molybdenum steel showed graphitization after several hundred hours. Steel pipe containing 0.50 to 0.70 per cent chromium, 0.45 to 0.65 per cent molybdenum and 0.10 to 0.20 per cent carbon has been standardized under the A.S.T.M. designation A-280. However, due to difficulties in grain-size control, the addition of one-half of one per cent of chromium does not seem sufficient to guarantee adequate carbon stabilization and a higher chromium concentration of 0.80 to 1.10 is being specified by some for such high-temperature piping, and there is a trend toward a chromium content of 1 to 1.5 per cent.

Reluctance to adopt steel of higher alloy content than 0.50 per cent chromium, and 0.50 per cent molybdenum was predicated upon welding considerations. Therefore, present specifications involving 1 per cent chromium and 0.50 per cent molybdenum are limiting the carbon content to 0.15 per cent maximum in the case of pipe and 0.20 per cent or less in the case of steel castings.

A recent survey of pipe being specified in various constructions showed a preference for the A-280 type over the 1 per cent chromium, 0.50 per cent molybdenum where temperature does not greatly exceed 900 F, and

more highly alloyed pipe where temperatures of 950 F and higher are involved. For temperatures in the neighborhood of 1000 F still higher alloy contents are frequently favored although the demands have not yet assumed well-defined lines.

Allowable stresses for the chromium-molybdenum steels fall off rather rapidly above 950 F, for which reason Mr. Kanter suggested the necessity of giving attention to certain other alloy steels if weight is not to be increased, and he mentioned that some engineers are advocating steels of 18 per cent chromium and 8 per cent nickel for temperatures above 1000 F. However, as high-temperature piping material, the austenitic nickel-chromium steels leave much to be desired, despite their strength and weight saving, as their cost is several times greater than the low-alloy steels. Although welding qualities of stabilized austenitic nickel-chromium steels are attractive, a problem is presented where they must be joined to ferritic steels.

The author further suggested that considerable promise for piping to operate at temperatures up to 1050 F may lay in the combination of molybdenum and vanadium as the principal alloying ingredients.

Methods of Firing Pulverized Coal

In an illustrated talk at the Fuels Session, **Otto de Lorenzi,** Director of Education, Combustion Engineerneering Company, described the three basic methods of firing pulverized coal, the various factors governing their selection, the influence of furnace design, and the control of furnace outlet temperature by use of vertically adjustable tangential burners. He followed this by showing colored motion pictures taken in pulverized-coal-fired furnaces, illustrating certain points covered in his talk.

Selection of firing method, he pointed out, is affected by size, shape and volume of furnace, type of furnace wall construction, quantity and characteristics of the coal to be burned, fineness of pulverization, character of load and method of ash disposal. However, since there are so many influencing variables, no hard and fast rules can be established and selection must be guided by actual knowledge and operating experience.

With vertical firing the burners are installed on relatively close centers in an arch near the top of the furnace and the coal is uniformly fired downward in a number of relatively flat streams across the width of the furnace. The primary air, employed for transport, enters with the coal; tertiary air in about the same percentage as the primary air is admitted under damper control around the fuel nozzles; and secondary air, which constitutes the major portion, is admitted horizontally through air ports in the front furnace wall. Such firing is well adapted to storage systems and where long flame travel is desired.

Development of direct-fired systems called for larger individual burner capacity that led to the horizontal turbulent burner which provided large concentrated fuel streams spread out over a wide area. Mixing of fuel and air are in the throat of the burner and the rotational effect produced by vanes in the burner housing establishes a high degree of turbulence. Individual burner capacities may be as high as 150 million Btu per hour, as compared with 30 million for the vertical type burner.

With tangential firing the burners are located in each of the four furnace corners, with individual burner assemblies consisting of two, three or four fuel nozzles surrounded by air inlet boxes equipped with guide vanes and dampers. The fuel and air streams are directed along tangents to an imaginary circle in the center of the furnace, imparting a rotary motion to the gases, and intense turbulence is set up where the four streams meet. Somewhat lower furnace temperatures are obtainable with this type of firing, because of increased heat transfer to the water-cooled walls due to the sweeping action of the rotating flame envelope.

One of the principal design requirements for large high-pressure steam-generating units is the maintaining of constant steam temperature over a wide range in load. This presents a problem because the products of combustion leaving the furnace must be sufficiently high in temperature to provide the desired steam temperature, yet avoid serious slag deposition. That is, if the furnace temperature is high enough at partial load to obtain full superheat at full load it may be too high to avoid serious slagging. Also, since heat absorption by the furnace walls varies with their cleanliness, as well as with the area subjected to direct radiation and convection transfer, to secure the desired furnace gas outlet temperature over a range in load, it becomes necessary to make a change in both the active furnace volume and the area of effective heat-absorbing surface.

These requirements, Mr. de Lorenzi explained, have led to the development of the vertically adjustable tangential burner which may be selectively tilted upward or downward through a range of 25 deg above or below the horizontal. Thus by directing the flame toward the upper zone of the furnace the desired gas outlet temperature will be maintained at light load, or when the walls are clean. For heavy loads, or when the walls are coated with ash, the entire furnace volume can be used, and the outlet gas temperature held to desired limits by tilting the burners down. The tilting is handled by remote control. By such control of outlet gas temperature it is possible to regulate steam temperature over a wide range in load. A supplementary gas bypass damper provides means for final incremental adjustment of steam temperature.

Superheat curves were shown for a large central station unit, equipped for tangential firing with vertically adjustable burners, in which total steam temperature in daily operation was maintained within ±3 deg F over a capacity range from 140,000 to 600,000 lb per hr.

Reduction in Air Pollution

This topic, as applied to small boiler plants, was the subject of a paper by **Parker A. Moe,** consulting engineer, Milwaukee. He expressed the opinion that no one should be permitted to take charge of or fire a boiler, other than residential, unless he has had training in the efficient operation of stoking equipment and understands the principles of combustion. Too often examinations for a fireman's license cover only the ability to operate boilers safely without regard to competency in burning coal efficiently and smokelessly.

The speaker observed further that failure of new installations to perform smokelessly or to avoid objec-

tionable discharge of flyash is frequently the result of unsound engineering practice or of conditions brought about by competitive bidding. In this respect, both the purchaser and the supplier of new equipment should realize that they have a joint responsibility. He urged that over-fire air jets be included in all stoker installations, regardless of type.

With regard to cinder reinjection with over-fire stokers, Mr. Moe advocated placing the furnace nozzles about 15 in. above the grate at the bridgewall and pitching them downward so that the stream will strike the grate at some point inside the front wall. The incoming cinders will then impinge on the tacky fuel bed and the ash will be discharged with that dumped to the ashpit.

In order to avoid carryover of fly ash from the furnace, it is important to maintain as low gas velocity as is consistent with good performance; and for this purpose a draft regulator is indispensable. There are many types of smoke indicators on the market, but one without an alarm is of little use. Moreover, one such device installed in the far end of a breeching serving several boilers will not locate the offending unit.

After enumerating the various points that he considered essential for incorporation in a smoke ordinance, Mr. Moe stated that administration of the ordinance should begin with an educational campaign in which the local press, fuel suppliers and dealers in fuel-burning equipment and combustion controls should participate. In this way, fuel users, the majority of whom are cooperative but uninformed, could learn the basic requirements of proper firing and the arrests of violators would be minimized.

Hydro and Steam Power

"Coordination of Hydroelectric and Steam-Electric Power in the Missouri River Basin" was the topic of a talk by **E. Robert de Luccia,** Chief, Bureau of Power, Federal Power Commission, at the first hydro-power session. This stressed the importance of hydroelectric developments in coordinated systems making possible better utilization of natural power and more efficient operation of fuel stations. Furthermore, total power costs are lower with such a combined system of operation.

Utility systems in the ten Missouri Basin states have an installed capacity of about 4,300,000 kw or roughly eight per cent of the U. S. total. Of this approximately twenty-five per cent is in hydro plants and sixty-five per cent in steam plants, the remainder being power derived from internal-combustion plants. At present in this vast area, covering one-sixth of the country, coordination of electric power facilities exists only to a limited extent.

That coordination has been limited is made apparent by the fact that in a large part of the Basin, communities are small and relatively far apart. Generating plants, usually steam, are of a size sufficient to serve the immediate community or area and are not large enough to justify the high-voltage interconnections required for effective coordination.

The proposed development of multiple-purpose projects in the Basin affords an opportunity not only to coordinate hydro and fuel-electric sources but also to interconnect and coordinate existing systems. As the smaller plants are retired they can be replaced with larger units thus deriving the benefit of lowered cost.

Among the hydroelectric plants constructed or proposed for the main stem of the Missouri River, representing an installed capacity of 1,180,000 kw, will be five plants of over 100,000 kw each.

Interconnection and coordination mean greater base loads and permit installation of larger steam-generating units and the obtaining of higher use factors in the most efficient plants with consequent saving in investment and operating costs. Additional benefit will be derived from the greater reliability of service. Also, greater use of capacity will result when advantage is taken of the diversity of peak loads in different parts of the Basin.

The multiple-purpose projects will involve various combinations of storage, flood control, navigation and irrigation. Power production thus becomes a secondary purpose for these projects. During periods of low stream flow, the river level will be regulated from reservoir to reservoir to serve best the needs of irrigation, navigation, power and other uses. While some projects are maintaining adequate water level others will be carrying the normal electrical load. As new hydro and steam-generating stations are interconnected in the system central dispatching points and power pool operations will be inaugurated. Studies of necessary transmission lines are now under way.

Most of the existing hydroelectric capacity in this area is located in Nebraska and is operated by the Nebraska Public Power System. The largest steam electric plant is in Omaha while the next in size is located in Des Moines.

Since the hydroelectric plants can take on load much quicker than steam plants, they will carry the peak portion of the load. The steam plants can then operate at their best efficiency to carry block loads for several hours each day or to supply base load. The portion of the load to be carried by each hydro plant will be determined to a large extent by the required release of water for navigation and other primary water uses, the location and size of new steam-generating plants and the distribution and location of the future loads.

At the second hydro session **Vincent Thieman,** Wisconsin Public Service Corp., presented a paper on "Correlation of Hydro- and Steam-Plant Operation." Speaking generally about the middle western states, he said that "almost all the hydro plants which are economically feasible have already been developed and are of comparatively small capacity, individually and in total. Because in general the hydro stations are remote from the large industrial centers, which have ready accessibility to coal, especially at the lake ports, the greater part of the electric load of the larger cities is served by steam plants." All major hydro and steam generating stations in the area are interconnected and are operated to supplement each other and to secure the advantages of each.

Seven electric companies having about 820,000-kw capacity in steam and 180,000 kw in hydro with their power systems interconnected are located in eastern and central Wisconsin. Approximately 600,000 kw of the

steam capacity is in the Milwaukee area. Some 160,000 kw of additional steam capacity is now being installed by these seven companies and more is projected for the near future. It is also possible that additional hydro plants may be developed on the Wisconsin River.

The advantageous combination of steam and hydro stations in the author's company is attributed to the location of the generating stations in the vicinity of the communities served; the automatic operation of hydro stations, the effectiveness of pondage at certain hydro stations to augment the firm capacity and the economic balance between hydro and steam plants resulting in low production costs. The system includes three steam plants totaling 70,000 kw and seventeen hydro plants with a capability of approximately 65,000 kw when the river flow is adequate and a firm capacity of 43,000 kw.

The cost of steam stations was about $100 per kw of capacity while that of the hydro plants ran about $260.

The intimate relationship existing between the generation and the load regarded as so essential is illustrated by the fact that the average distance which electricity was transmitted by the author's company was 36 miles.

Hydro plants are classified as either peaking or run-of-river. The former can manipulate the river flow, storing water during the night and generating maximum output at times of peak load, while the latter type must take water as it comes at a more or less uniform rate. For a hydro plant to operate as a peaking plant a pond of moderate area is necessary upstream, the level of which can be varied to a modest extent, so that the stream flow can be utilized to fit the load curve.

The cost of energy from water power usually is considerably less than that from fuel but is sometimes worth considerably less because of the great variations in hydro output over the seasons and years. In the area described less than half the hydro energy is dependable and useful by itself; the remainder is surplus or dump, with little value alone. Addition of sufficient steam capacity to the hydro can make the entire output useful and result in lower production cost.

The greatest economy in combined operation is realized when the hydro plants carry the peak loads and the steam stations run at base load. Hydraulic generating units can be put on the line in much less time and can follow rapid load swings more readily than can steam. If steam stations carry the base load the firm capacity of peaking hydro plants will be increased for hydro peaks will be of shorter duration.

Firm capacity is the demonstrated dependable load carrying ability of the hydro-electric generating plant during peak periods assuming minimum recorded stream flow conditions. The firm capacity of a peaking hydro plant depends on the shape of the load curve as well as on the steam capacity available for base loading.

Steam plant capacity is sometimes reduced by limitations in boiler output or by cooling water of high temperature. The outage time for boilers, steam turbines and hydraulic units was given as eleven per cent, five per cent and one per cent, respectively. However, it was said that most of the new steam plant capacity will probably be available 99 per cent of the time.

To realize the most effective operation of reservoirs and hydro stations a constant knowledge of existing water and weather conditions upstream and predictions of their probable results is required.

Gas Turbines

At the Gas Turbine Session on Wednesday afternoon there were three papers. The first was by **John I. Yellott** who reported on progress with the coal-burning gas-turbine locomotive under development by the Locomotive Development Committee of Bituminous Coal Research; the second, by **L. N. Rowley** and **B. G. A. Skrotzki,** discussed the place of the gas turbine in the stationary power plant; and the third, by **Paul R. Sidler,** dealt with developments by Brown Boveri Corp. in Switzerland. An unusually large attendance at this session gave evidence of the interest in this subject.

The authors of the second paper stated that to date twelve commercial power units (largely foreign), aggregating over 80,000 kw have been built or are on order. For capacities of 6000 kw and less no water is needed, but above this capacity it has been found more economical to divide compression into two or more stages with intercooling by water. Typical performance at full load with 1100 F inlet gas for a 10,000-kw unit showed 19,000 Btu per kwhr for the simple cycle without intercooling; 16,000 Btu for the same cycle with one intercooler; 15,000 Btu for a two-turbine arrangement with intercooler; and 13,000 Btu for the regenerative cycle with intercooling and reheat. Gas turbines built for 30 per cent efficiency are said to cost about 50 per cent more than those for 20-per cent efficiency.

For industrial power applications where recoverable process heat is a factor, the gas turbine falls between the steam turbine and the diesel engine; although to date comparatively little appears to have been done to explore the possibilities of the gas turbine in this field.

The authors presented the results of studies of several hypothetical layouts and applications and concluded therefrom that the gas turbine presented considerable versatility.

Mr. Sidler showed pictures of a number of gas-turbine sets constructed by his company. Included was a 12,000-kw two-shaft set built for standby and peak-load service in the Filaret Power Station in Rumania and operating with natural gas. Tests showed thermal efficiencies ranging from 10 per cent at one-quarter load to 23 per cent at full load. This set required slightly over 5 minutes to start from standstill to full speed and an additional $2^1/_2$ minutes to full load.

Another, smaller single-stage unit of 4000 kw destined for a power plant in Chimbote, Peru, was shown on the test floor. This had shown an overall efficiency of 19 per cent.

A 10,000-kw two-stage set for Lima, Peru, carrying a 28 per cent guaranteed full-load efficiency, is now being tested at the Brown Boveri works; and two 4000-kw sets to operate on natural gas at an oil refinery in southern Iran are under construction, as is also a new 4000-hp gas-turbine locomotive. On order is an oil-fired gas-turbine locomotive of 2500 hp for the Great Western Railway in England.

Among recent sets ordered are two units for installation in Switzerland to supplement a hydro system from November to March when the average air temperature is around 41 F, it being a characteristic of the gas turbine that the output and efficiency increase as the air temperature goes down.

Feedwater Treatment

In the first of two papers presented at the feedwater session, **Lyle B. Porter,** Director of Research, Illinois Water Treatment Company, described the demineralizing or de-ionizing process of water treatment. In this process acid absorbing resins are used to remove the acids formed by the hydrogen exchange, in which all cations including sodium are exchanged for hydrogen in the zeolite forming the corresponding acid in the effluent water.

The paper described the limitations of the two general classifications of water treatment in common use prior to development of the organic or resinous-type ion exchangers; namely, base-exchange systems and coagulation and precipitation. Excessive blowdown and the possibilities of foaming and priming were given as the shortcomings of zeolite-softened water for boiler feed. The lime or lime-soda softener, although providing adequate treatment in many cases, does not accomplish complete removal of dissolved solids, and with water high in sodium salts very little reduction is possible.

To provide better water required by the higher pressures and large capacities evaporators operating on either raw or treated water are used. If makeup is 4 per cent or less evaporators can be justified, but if it is high and the heat balance not properly adjusted this can be a very expensive means of providing makeup water.

The paper told how in 1930, during attempts to develop more stable compounds, it was noted that organic zeolites had definite hydrogen-exchange properties. Thus, instead of exchanging the calcium and magnesium in the water for sodium in the zeolite, all cations including sodium could be exchanged for hydrogen in the zeolite forming corresponding acids in the effluent water. The carbonic acid thus formed breaks down into CO_2 and H_2O and the other acids are then neutralized by the addition of caustic or soda ash blended with sufficient raw or sodium zeolite water. This process, referred to as dealkalization, produces a water similar to and often superior to lime or lime-soda treated water.

The advent of this phase in water treatment led to the development of various resins including the latest acid-absorbing ones which now make possible the production of water entirely free of dissolved solids.

The CO_2 present in the freshly treated water following the de-ionizing process may be removed by one of several recognized procedures, depending on the completeness of removal desired. Complete removal can be accomplished by vacuum degasification while counter-current air degasifiers will reduce the CO_2 content below 10 ppm with further reduction carried on in open-type feedwater heaters.

As the de-ionization process removes only those solids that are ionized, silica which has a very low ionization constant remains unchanged. The general procedures for the reduction of silica involve the use of metal oxides or hydroxides for the absorption of the silica molecule. A residual of 1 to 2 ppm of silica may be expected.

A new process recently perfected incorporates silica removal by ion exchange in conjunction with the de-ionization process. An installation designed to remove silica from an original concentration of 8.5 ppm SiO_2 to an effluent concentration not to exceed 0.2 ppm at flow rates of 300 gpm is being made. When silica is removed by ion exchange it is converted to fluosilicic acid which has a high ionization constant. Complete absorption by the resins is then accomplished.

Experiments are being conducted to determine the possibility of slurrying the hydrogen-exchange resin with calcium fluoride for silica removal. This would result in substantial reduction in cost over sodium fluoride

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The second paper presented at the Feedwater Session was on "The Removal of Carbon Dioxide from Alkaline Waters" by **A. E. Kittredge,** Vice President and Chief Engineer, Cochrane Corp. The paper stated that engineers responsible for the protection of steam distributing and condensate return piping and the selection of boiler water treating and degasifying apparatus strive to seek the lowest possible CO_2 in the condensate return systems by the selection of proper equipment designed for that purpose. It further stated that "the distinction between zero-free carbon dioxide at the outlet from a deaerator and minimum free CO_2 content in condensate return lines is not yet adequately recognized by the users of deaerating equipment." Zero-free carbon dioxide is most easily produced when the water treated contains bicarbonate alkalinity; the effort required to accomplish this being roughly inversely proportional to the bicarbonate alkalinity concentration.

The paper observed that the cheapest method of water softening, the use of sodium zeolite, does not reduce the bicarbonate alkalinity at all and therefore affords no protection against the presence of excessive free CO_2; while the most expensive method, de-ionization, reduces bicarbonate alkalinity to 5 ppm or less but also converts most of it into free CO_2 requiring that it be removed while in a highly ionized state. It was also observed that there will always be a problem of CO_2 removal by mechanical deaeration. This is caused by the necessity on the one hand of not only removing all free CO_2 from alkaline waters but of breaking down the bicarbonate alkalinity to reduce the potential CO_2 generating capacity; on the other hand of removing free CO_2 from waters substantially neutral, under conditions of high ionization.

The purpose of this paper was to present a method of calculation based on several recent studies dealing with the nature of carbon dioxide in bicarbonate waters.

The CO_2 indicated by titration in alkaline water is not exactly the total quantity of CO_2 existing in the form of carbonic acid, H_2CO_3, nor the amount of CO_2 removable by deaeration nor is it even the total CO_2 in solution. The removal of CO_2 by mechanical deaeration from a bicarbonate water begins at a pH value of about 8.3 at the point where titration indicates the complete absence of free CO_2. Carbon dioxide in an alkaline solution originates to some degree from ionization of an alkaline salt. This liberates the bicarbonate ion, HCO_3, to combine with the hydrogen ion H produced by the ionization of the water to form carbonic acid, H_2CO_3. Carbon dioxide from this source is not indicated by titration but is present and is removable by deaeration.

Another source of CO_2 in a bicarbonate solution is the breakdown of two units in the bicarbonate ion, HCO_3 to form the normal carbonate ion, CO_3, water and CO_2. The CO_2 formed by combination of bicarbonate ion with hydrogen ion of water is removable by deaeration.

The remaining CO_2 formed in solution may be due to absorption from atmospheric air or subaqueous vegetation or from decomposition of organic matter.

Atomizing vs. Tray-Type Deaerators

By E. J. BOOKOUT
Cochrane Corporation

A discussion of the conditions for which each type of deaerator is best adapted. It is pointed out that thermal difference, due to steam pressure drop across the atomizer still makes the tray type preferable for many power-plant applications.

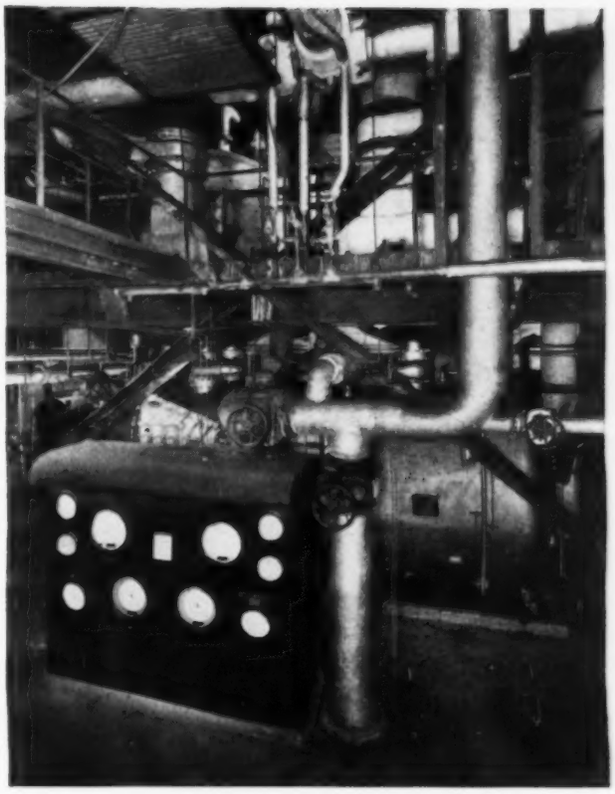


Fig. 1—This 1,000,000-lb per hr atomizing deaerator is installed in a mid-western public utility. The two lateral atomizer compartments, only one of which has yet been lagged in this view, can be seen above the horizontal storage tank.

DEAERATING feedwater heaters are installed in power plants for two fundamental reasons: (1) Thermal efficiency, as compared with open or closed heaters; and (2) Removal of oxygen or other corrosive gases for the protection of power-plant boilers and equipment.

Open heaters of either the tray or jet type will heat water to within 2 to 3 deg F of the steam temperature. Because of this small terminal difference, they largely supplanted use of closed-type heaters as the primary feedwater heater unit years ago.

With the development of the deaerating heater, even this small temperature difference disappeared and the modern deaerator will heat the water to the full temperature corresponding to the saturated steam pressure maintained in the unit. In fact, many plants have selected deaerators in place of open heaters for the gain to be obtained by this greater thermal efficiency.

The removal of oxygen is important in protecting economizers and boilers against corrosion and in most modern plants this point alone makes deaeration equipment mandatory. To provide efficient deaeration the apparatus must accomplish three cardinal functions:

(1) Heat the water to the full saturated steam temperature in order to reduce the solubility of the dissolved gases to the minimum.

(2) Agitate the heated water sufficiently to bring the liberated gas bubbles to the surface where they can be swept away.

(3) Provide an adequate vent rate to sweep away the liberated gases and to maintain the partial pressure of such gases in the steam atmosphere at the minimum.

The solubility of a gas is dependent on temperature and its partial pressure in the vapor in contact with the liquid. Therefore, unless the liberated gases are carried away by means of proper venting, it is possible for such gas to re-dissolve in the water. It is the usual practice to equip deaerators with vent condensers to recover the heat in the vent vapors by transfer to cooler water entering the heater.

Tray-Type Deaerators

Until a few years ago, the deaerating heater was confined to the tray type which consisted basically of a series of trays or pans over which the water cascades through an atmosphere of steam. Thus a time element is provided to insure adequate contact of steam and water and the trays further serve to distribute the water into thin films so that as the gases are liberated due to temperature increase, the release of such gases through the thin water films is accelerated by the agitating effect obtained.

Steam is passed through the tray bank, either in parallel or countercurrent to the water flow. In such equipment the thermodynamic efficiency is practically 100 per cent and if properly designed, will reduce oxygen to very low values, i.e., usually less than 0.005 ml per liter. Fig. 2 illustrates a cutaway view of a modern tray-type deaerator.

Atomizing Deaerators

About ten years ago, improvements in naval and merchant vessels incorporated a feedwater cycle, where deaerating feed tanks were substituted for the conventional closed-type heater. For this purpose the tray-type deaerator was entirely unsuited since it was necessary to provide efficient heating and complete deaeration, despite the pitch and roll of the ship. In 1929 and 1930

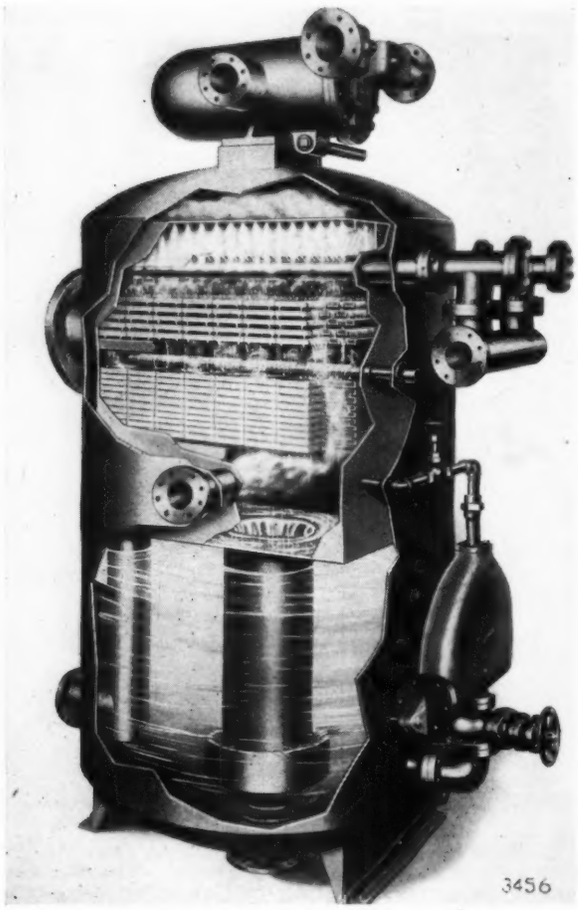


Fig. 2—Tray-type deaerator utilizing trough-shaped heating trays (top) and slotted air-separating trays (beneath). Feedwater enters header at right, spills through heating and air-separating tray banks, and is stored in lower compartment.

Cochrane Corporation developed a design of deaerator now generally known as the atomizing type, which was applied to marine use as it would function despite the motion of the vessel in which it was installed.

The atomizing-type deaerator satisfies the basic requirements for deaeration in that it raises the water temperature to the boiling point at the given operating pressure and it provides tremendous agitation by exposing the greatest possible surface area of the liquid to the steam by blasting it into a fog or mist. Finally, it utilizes sufficient steam to remove satisfactorily the liberated gases from the unit. Fig. 3 illustrates a modern atomizing type deaerator employing a movable type atomizer.

Stationary Applications for Atomizing Deaerators

While the atomizing-type deaerator was designed principally for marine use, it has found other applications where the tray-type deaerator is not well suited, such as in the hot-process softener where the pretreated unfiltered water is to be deaerated. Such water does not usually deposit on an atomizer but would form incrustation on trays. With the atomizing deaerator continuous operation can be obtained with minimum maintenance. Also, the atomizing deaerator may be advantageously applied to the deaeration of acid-treated waters, but due to the simplicity of design, it can be more readily protected through use of corrosion-resistant metals.

Because of this relatively new development, engineers frequently are of the opinion that it is a superior means of deaeration and will reduce oxygen to a lower degree than will the tray type. Actually, this is not correct. From the standpoint of oxygen and carbon dioxide removal both tray and atomizing type deaerators are on a par when properly designed. From an operating standpoint the major difference lies in the fact that the atomizer utilizes a steam pressure drop to obtain the necessary energy to create a high velocity steam jet. This pressure loss results in a lower temperature of the steam within the deaerator so that the final water temperature is limited to the temperature of the saturated steam beyond the atomizer. Thus, if there is a pressure loss of 1.0 lb through the atomizer the temperature will be 2 to 3 deg F below the temperature of the steam available. In comparing the two types, the tray-type unit has a very definite thermodynamic advantage as it operates with practically no pressure drop.

Fixed Orifices vs. Variable Orifices

Deaerating atomizers may be of the fixed-orifice or the movable-orifice type. The movable-orifice design automatically maintains a constant steam pressure drop over the entire operating range of the heater, thus minimizing the terminal difference between steam and water temperatures. With the fixed-orifice type atomizer the steam pressure loss will vary as the square of the velocity of steam flow through the orifice.

Assume, for instance, that $^1/_2$-lb pressure drop will

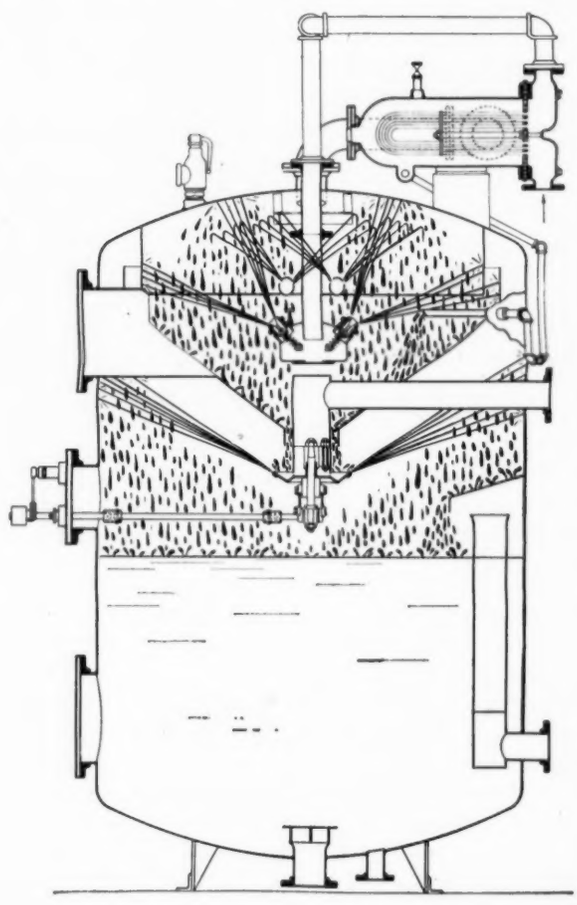


Fig. 3—The circular atomizer shown here is adjustable from the front to provide a fixed pressure drop at all loads.

accomplish adequate deaeration. Assume further that this condition prevails at one-quarter load. Then, with a fixed-orifice atomizer operating at full load, the pressure drop required for adequate velocity to provide deaeration becomes sixteen times as great, or 8 lb. The temperature difference is 20 deg F. If the deaerator were operated at 5 psig (20 psi absolute), steam could not enter the deaerator, much less accomplish adequate deaeration. Conversely, a fixed-orifice deaerator designed for an assumed pressure drop of $^1/_2$ lb at full load could not admit sufficient steam at fractional loads to provide the velocity necessary to accomplish deaeration.

With the variable orifice, the admission of steam is throttled as the load is reduced, usually by a weighted or spring-loaded valve. Thus the pressure loss, and the temperature difference which supplies the energy to accomplish deaeration, are constant over varying load ranges. For example, if the atomizer is set to maintain a steam pressure drop of $^1/_2$ lb, the temperature loss at an operating pressure of 5 psig is 1.4 deg F. With the tray-type deaerator even this temperature difference is eliminated.

Limitations of Atomizing Deaerators

It should be recognized that the atomizing deaerator depends upon energy obtained through a high-velocity steam jet to bring about efficient deaeration. The amount of steam which will enter the unit is dependent upon the quantity and temperature of the inlet water. Obviously, if the temperature difference between the inlet water and the steam is fairly high, there is no difficulty in obtaining sufficient volume of steam to create the required velocity. But, in many plants, the average temperature of the water entering the heater is quite high, usually because of a high per cent of hot condensate returns, and the temperature difference between the steam and water may be quite low, resulting in a small amount of steam entering the unit. In this case, the steam velocity through the atomizer may be inadequate to produce deaeration.

The steam pressure applied to the heater should also be considered in this connection. Obviously, as the pressure increases the specific volume decreases and results in reduced velocities at the higher operating pressures. Here again, under some conditions, the volume of steam passing through the atomizer might be insufficient to accomplish its purpose.

Thermal Efficiency of Tray-Type Deaerator

It has been indicated in the foregoing discussion that the tray-type deaerator enjoys greater thermal efficiency than the atomizing type due to negligible steam pressure losses in the tray-type heater as compared to losses through atomizing orifices. In plants where sufficient exhaust steam is available for feedwater heating purposes, this produces a definite economic advantage in favor of the tray-type heater since the higher feedwater temperatures obtained can be measured directly as fuel savings.

The old rule-of-thumb of approximately 1 per cent of fuel savings for each 11 deg F temperature rise holds in this case. When steam is bled from a turbine for single-stage feedwater heating, this saving is roughly reduced by approximately 50 per cent, since this reduces the quantity of steam going to the condenser where appreciable heat loss is encountered in the condensing action. With a multistage turbine, where several bleed points are utilized, the advantage of the tray type over the atomizing type, from a thermal standpoint, is progressively reduced.

Selection of Atomizing Deaerators

If the installation of an atomizing-type deaerator is contemplated where the steam pressure may fluctuate, the type of atomizer employed should be carefully considered, particularly if the heater is of the storage type. Under such conditions, the heater may be required to operate over a considerable steam pressure range and a sudden steam pressure drop will result in a corresponding flashing of hot water in the storage space. In this event it is possible for the flow of steam to reverse and travel from the heater to the exhaust line for a short period. If the orifice is of the fixed submerged type, this reversal of flow might result in water being carried into the steam mains or even to the auxiliaries.

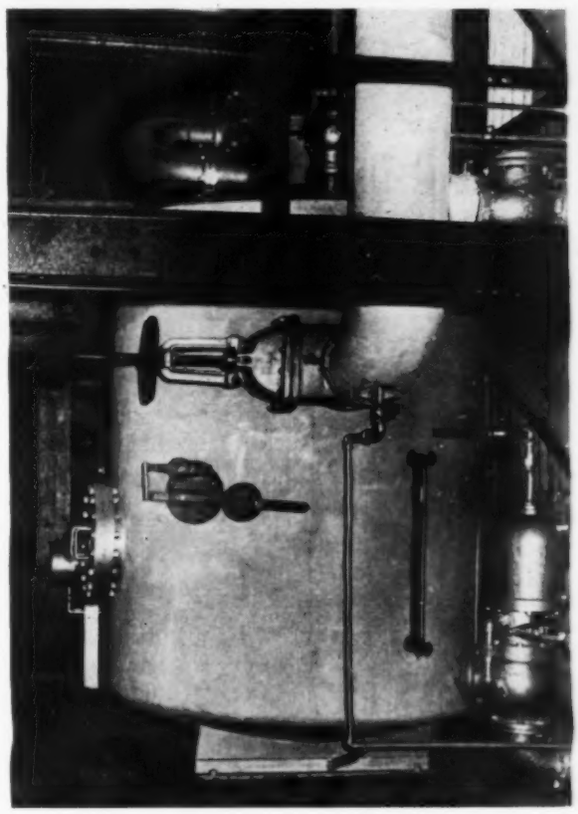
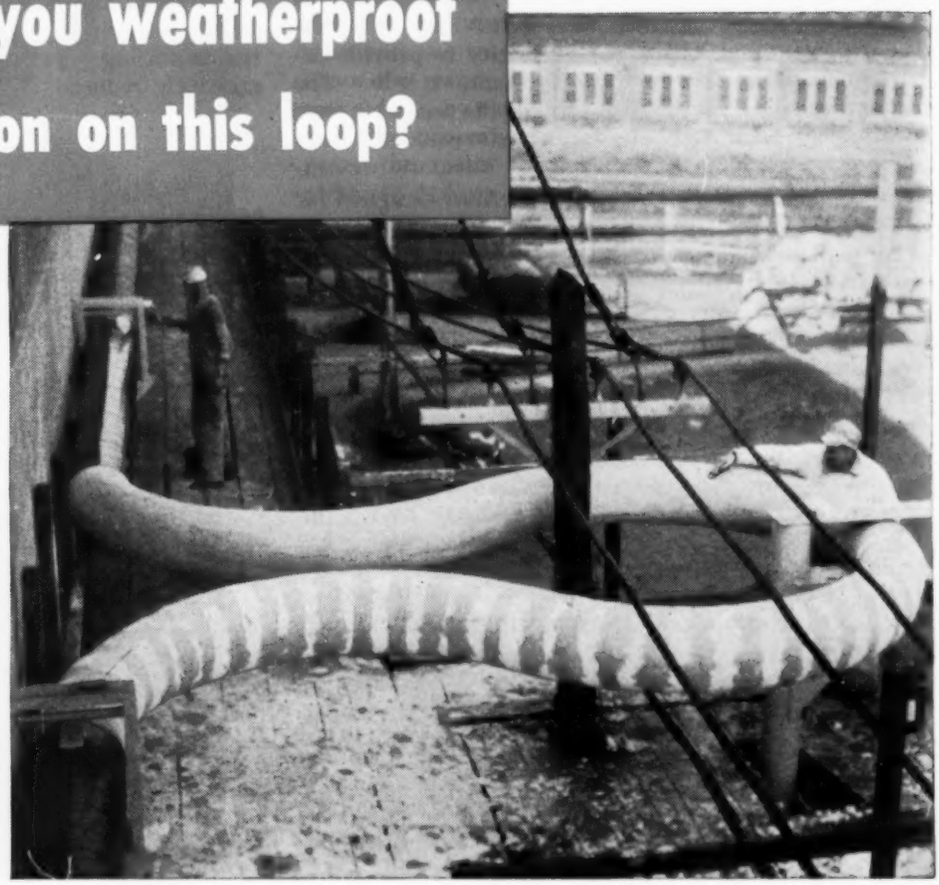


Fig. 4—Vertical atomizing deaerator of 175,000 lb per hr capacity installed in a southern paper mill. It supplies the boilers with 100 per cent makeup heated and deaerated to "zero-oxygen" from 50 F city water supply.

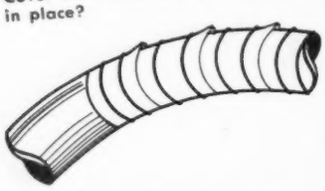
With the types shown in Fig. 3, the movable orifice acts as a check valve preventing such backflow and simultaneously holding the pressure in the heater, thereby preventing rapid flashing of stored water.

In conclusion, it should be emphasized that there are many types of applications for many types of deaerating equipment, but each set of conditions, if properly analyzed, will indicate the proper type of equipment to install.

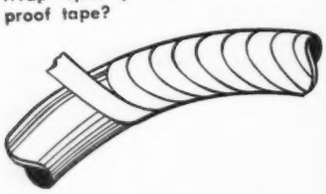
How would you weatherproof the insulation on this loop?



☐ Cover with roofing paper wired in place?



☐ Wrap spirally with weatherproof tape?



☐ Trowel on two coats of plastic?

Here's what the Armstrong engineer recommended:

This expansion loop on a 10" steam line suspended 14' above the ground serves a manufacturing plant in a moderate climate. The line is insulated with 2-inch thick 85% Magnesia. Straight sections have been weatherproofed with roofing paper wired in place.

Although roofing paper is economical weatherproofing for straight pipe sections, it isn't practical on the loop. Edges of the paper won't fit snugly to the outside radius of the loop. Rain and moisture will enter, reducing the efficiency of the insulation.

Spirally wrapped weatherproof tape will provide long-lasting protection if each lap is sealed with a weatherproofing sealer all around. However, this is slow, painstaking handwork—a costly operation.

The Armstrong engineer recommended Armstrong's Insulmastic trowelled on in two coats, each $\frac{1}{8}$" thick, which will dry to a final thickness of $\frac{3}{16}$". It is applied over a two-coat asbestos cement finish, the last coat of which has been left rough to provide a key. The Insulmastic is flexible enough to "give" with the insulation as the loop expands and contracts. It goes on rapidly, does not crack or scale, and provides many years of dependable protection against the deteriorating effects of weather.

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The Fuel Industry of Japan*

WILLIAM T. REID
Battelle Memorial Institute

The author, recently returned from Japan where he made a study of the fuel situations, cites the war experiences in low-temperature carbonization and production of synthetic fuels and refers to the present drop in coal production to approximately one-fifth of the yearly war output.

THE restoration of the coal industry of Japan to levels necessary to maintain a controlled peacetime economy is one of the greatest problems faced at present by the occupation forces. Although the Allied Powers are not directly involved in the operation of the coal mines, advisory assistance is being given the coal industry on both technical and economic problems in the attempt to obtain production adequate for present needs. Peak production of coal in Japan occurred during the war, and amounted to about 66,000,000 metric tons per year, whereas at present only about one-fifth that amount is being mined. Lack of maintenance of mining equipment, shortages in labor and materials, and generally unfavorable post-war conditions are jointly responsible for this decrease.

Although water power is an important source of energy in Japan, considerable quantities of coal are consumed in the generation of steam for power purposes. Large amounts also are involved in the production of metallurgical coke, but the low-volatile bituminous coals required for blending to produce high-grade coke are not available on the home islands. Previously, these blending coals were imported from north China or Manchuria, but such sources are no longer at the disposal of the Japanese. Economic reasons prior to 1941 prompted fuel engineers in Japan to seek substitutes for these blending coals, with the result that two low-temperature carbonization processes were developed yielding a semi-coke containing from 15 to 25 per cent of volatile matter. One of these plants has produced more than 400,000 metric tons of semi-coke since its initial operation in 1937, the entire production being used for blending in amounts ranging from 10 to 25 per cent of the charge. The resulting coke was suitable for use in small blast furnaces having an output of about 200 tons of pig iron per day, but for larger blast furnaces some low-volatile coal was still necessary in the blend.

Other low-temperature carbonization plants were operated primarily as a source of liquid fuel. Having only meager domestic supplies of petroleum, Japan early in 1937 began an intensive developmental program on the production of synthetic liquid fuel from coal, but it was not until after the start of the war that commercial plants were constructed. Operational difficulties with the Bergius process prevented its success on a commercial scale, while the Fischer-Tropsch synthesis gas process, although more easily operated, never achieved a flourishing status primarily because of difficulties in obtaining suitable catalysts. Low-temperature carbonization, on the other hand, was successful from the start. In the period 1940–1945 this industry produced more than seven times as much liquid fuels as was made from coal by all synthetic liquid fuels plants. The most satisfactory low-temperature carbonization plants were of German design and consisted of both Lurgi and continuous vertical Koppers units. Japanese-designed plants usually were unsuccessful, principally because they were intended to carbonize strongly caking coals, and inadequate provisions were made for keeping heat-transfer surfaces clean. The tendency of such coals to agglomerate into large sticky masses also was not sufficiently recognized, with the result that conveying mechanisms for moving the charge during carbonization became inoperable.

Chemical utilization of coal in Japan was primarily for the production of ammonia, useful in wartime as a source of nitrates and in peacetime for the production of fertilizers. Since synthesis gas rich in hydrogen is the first requirement in the process, gasification methods were important and were developed largely along conventional lines. The principal source of gas was the water-gas generator using coke, the Otto design being a favorite. At least one plant had installed Fiag gas-generators using noncaking coal, while four plants had each installed one Winkler generator based on an exact duplication of the German design. As a comparison, it is interesting that only five plants had installed Winkler generators in Germany and were operating them during the war. As a source of oxygen for the Winkler generators, the Linde-Frankl system was used, but leakage of valves in the heat exchanger system prevented obtaining oxygen of high purity or in the amounts originally desired. Since air was also used in the blast of these Winkler generators, nitrogen being required in the synthesis gas, oxygen of low purity was satisfactory although the output of the plant was reduced about three-fourths of the design capacity.

Source of Lubricants

Shortages of lubricants near the end of the war forced mine operators to install small-scale low-temperature carbonization plants to recover coal tar from high-ash waste coals, termed "bota." These bota plants, usually

* Presented at the Spring Meeting of A.S.M.E., Tulsa, Okla., March 2–5, 1947.

of crude workmanship and constructed of odds and ends, were self-heating, that is, a portion of the charge was burned to supply the heat necessary to volatilize tar from the remainder of the charge. The yields were small. Using bota having an ash content of 70 per cent or more, the tar obtained seldom exceeded one per cent of the weight of bota charged. The residue was almost entirely ash, but at some mines where lumps of lower-ash coal were included in the charge the residue contained semicoke which was hand-picked for use as domestic fuel by the miners. The coal tar obtained was used directly as a lubricant for mine-car wheels and for the pulleys of the cable haulage systems in common use. However, it was low in lubricating value and useless in highly loaded bearings. Many attempts were made to produce semi-solid grease by such procedures as adding bentonite or by processing the tar with gelatinous seaweeds and lime, but the greases so formed were of very poor quality compared to industrial lubricants having a petroleum base.

Domestic Fuel

In Japan only a minor amount of coal is used as domestic fuel. Central heating plants are almost unknown, small braziers usually burning charcoal serving to heat each room. Since charcoal is expensive and often is not available in required amounts, semi-coke having high reactivity is also used as fuel, as are briquets made from semi-coke with the addition of large amounts of lime. Besides serving as a binder, the lime acts to reduce the amount of sulphur released in the products of combustion and thus removes the most annoying feature of a flueless open fire. Cooking is done on braziers of this same type.

Motor Fuel

Since about 30,000 Japanese motor vehicles have been equipped with portable gas producers, gasoline having been unobtainable for civilian purposes during the war, the demand for solid fuels for this purpose has been considerable. Lack of charcoal again made it necessary to use semicoke although the amount available was insufficient to meet the demand, thus raw wood also was commonly used. It is interesting to note that whereas most countries using portable gas producers place an upper limit of about 5 per cent on the amount of ash permissible in the fuel, in Japan no such specification exists and semi-coke containing as much as 30 per cent ash is used regularly. As a result, fires must be cleaned frequently, and in the larger cities such as Tokyo piles of clinker in the streets are a common sight. Nevertheless, the vehicles still operate.

The imitative nature of Japanese workmen, well shown by their copying of toys and other inexpensive items for sale to the Western countries, has been carried over into the field of fuel utilization. With few exceptions, the principal equipment in their plants has been designed by foreigners. German practice has been followed most closely in carbonization and gasification, while American and English designs predominate in chemical plants such as for ammonia synthesis. Although the well-trained Japanese engineer should be capable of originating new types of equipment or of developing improved processes, the stigma attached to failure apparently is a potent deterrent to his suggesting any process which has not already been proved successful. As a result, foreign developments have been followed closely and serve as the basis on which the Japanese engineer makes his choice.

Fuel Research

Research on the use of fuel has been conducted on a moderately large scale, the Imperial Fuel Research Institute at Kawaguchi having employed more than 250 men prior to the war. Among the problems currently being studied are: electrostatic cleaning of coal, experimental carbonization of coal in a one-ton oven, production of briquets for domestic fuel, solvent extraction of coal, internal combustion engine burning pulverized coal, and the fields of utilization of low-quality lignite.

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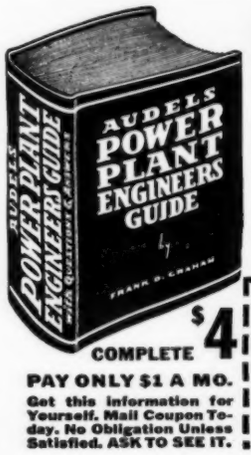

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Materials in Boiler Feed-Pump Construction

By H. L. ROSS,
Ch. Eng., Centrifugal Pump Dept.,
Allis-Chalmers Mfg. Co.

In this paper, presented at the 1947 Midwest Power Conference, the author reviews the influence of various factors on corrosion-erosion when employing carbon-steel. Among these, low pH of the feedwater is especially detrimental. Use of corrective materials for pump parts is discussed.

UNTIL a few years ago carbon steel was the accepted material for casings of high-pressure boiler feed pumps. This continued in spite of occasional troubles due to corrosion-erosion of the fits and high velocity passages. However, the trend of boiler feedwater treatment has been toward supplying the boiler with the best feedwater with little regard to its suitability for the boiler feed pumps and valves.

This problem has been the object of an intensive study by a joint committee of engineers of pump manufacturers and public utilities, and sufficient information has been assembled so that there is good assurance of elimination of these troubles on new pump installations.

Causes of Corrosion-Erosion

OPERATING CONDITIONS—A study of such factors as capacity, pressure, temperature, method of drive, etc., seems to indicate that these have little bearing on the trouble, although there does seem to be some evidence that a higher temperature is more conducive to trouble.

FEEDWATER—If feedwater be considered from standpoint of pH value, the oxygen content, the amount of solids, the use of chemical treatments, etc., the pH value seems to be the most significant and it appears that the higher the pH value the less chance there is of trouble with carbon-steel parts. For instance, where the pH is above 9.0 there is only one chance in five of having trouble, whereas with pH below 8 there is indication that three pumps out of four will give trouble with carbon steel.

SODIUM SULPHITE—The addition of this chemical either ahead of the pump or directly into the boiler may possibly lead to trouble, although the results are not very conclusive. However, it seems that where the pH is below 8.5 there are more cases of trouble where sodium sulphite is used. It also makes very little difference whether the sodium sulphite is introduced ahead of the pump or directly into the boiler. The theory is that the sodium sulphite decomposes in the boiler into H_2S and is carried over in the steam and reduces the pH value of the condensate. Where the pH value is above 8.5 the use of sodium sulphite does not seem to indicate a trend in either direction. However, the general results with sodium sulphite are so inconclusive that the above statements must be used with caution.

CAVITATION—A study of various failures indicates that cavitation definitely is not a factor. Cavitation is a phenomenon associated with a liquid which vaporizes and then collapses, causing a combined mechanical and chemical attack. It is therefore associated with the low-pressure areas in a pump while the troubles under discussion occur just as much in the high-pressure stages of the pump where there is no possibility of vaporization as in the low-pressure stages.

PUMP DESIGN—All designs of feedwater pumps have experienced these troubles, which do not seem to be more common to one design than to another. The troubles are associated with higher velocities but it would be impossible to design a pump with velocities low enough to avoid this attack.

WORKMANSHIP—This factor does seem to have some bearing on the start of the trouble, particularly as far as interstage leakage is concerned, since poor machine work will lead to an initial leakage which will start cutting on cast steel. However, if the material is susceptible to attack the pump will usually fail later in another portion, such as the casing volutes which are subject to high velocities.

Furthermore, it is significant that when there is leakage behind a bronze ring, for instance, the carbon steel may erode tremendously with no measurable wear on the bronze part, which is a softer material and subject to the same velocity. This would indicate a chemical rather than a mechanical action.

When this trouble was first encountered in volutes or castings, it was thought to be due to poor steel castings, particularly to sand inclusion on the surface. To determine if this were the case, a carbon-steel plate volute liner was installed, but it was attacked just as badly as the less dense carbon-steel casting. In this installation the pH was raised by recirculating boiler water to 9.0 with little if any reduction in trouble but when the pH was raised to 9.5 the trouble ceased entirely with both the steel casting and the steel plate liner. Subsequent changes to 18–8 fits and liners stopped the action even without recirculation.

Remedies

FEEDWATER CONDITION—To summarize, there are no iron-clad rules for avoiding trouble with carbon-steel

parts but, in general, it is advisable to keep the pH value above 9.0 or 9.5 by recirculation, or by the addition of caustic and to eliminate sodium sulphite. It may also be helpful to alternate the pumps in service, the theory being that the idle pump will build up a protective film which causes some measure of protection after it is in operation.

PROTECTIVE COATING—Existing pumps may have the fits between stages built up with 18–8 or other stainless material and may even have the volutes lined with stainless steel, although this is a very expensive process which usually involves sending the pump back to the factory.

Use of a coating of bakelite lacquer is reported in the paper by Wagner, Decker and Marsh at the 1946 annual meeting of the A.S.M.E. This consists of a baked-on coating only 0.0003 in. thick which was practically unattacked after a 500-hr accelerated test. However, there may be difficulty in applying this coating to closely machined surfaces and keeping it intact during assembly.

MATERIALS—A more logical and positive solution to the problem is the use of the proper materials, which will take care of practically any feedwater condition. In general, it appears that a 5 per cent or better chromium steel is practically immune to attack, but there are other factors which may make the selection of another material a better one for the particular installation. The following table shows the characteristics of some of the most commonly used materials on a comparative basis.

COMPARISON OF BOILER FEED PUMP MATERIALS

	Material					
	Nickel Cast Iron	Carbon Steel	4–6% Chrome	12–14% Chrome	18–8 Stainless	25–20 Stainless
Corrosion resistance to feedwater	Good	Poor	Very good	Very good	Excellent	Excellent
Tensile strength	50,000	70,000	100,000	110,000	75,000	75,000
Resistance to shock	Poor	Good	Good	Good	Excellent	Excellent
Coeff. of expansion × 10^6	6.0	5.6	5.5	5.5	9.0	9.0
Heat treatable?	Yes	Yes	Yes	Yes	No	No
Weldability	Poor	Good	Fair	Fair	Excellent	Excellent
Machinability	Excellent	Good	Good	Good	Difficult	Difficult
Initial cost	Low	Moderate	Moderate	High	High	Very high

CAST IRON—It will be noted from the table that nickel cast iron is shown as fairly resistant to corrosion. The Detroit Edison tests reported by Wagner, Decker and Marsh indicate that ordinarily cast iron is attacked about one-third as much as cast steel but our experience with 1-per cent nickel cast iron indicates that it is much better than this. With temperatures up to 400 F and pressures up to 1200 psi 1-per cent nickel cast iron has shown no failures due to corrosion-erosion. This is true even in installations where carbon steel has been attacked. In one case a heater drain pump at 400 F with a steel casing failed in a few months time, and a cast-iron casing which was substituted in emergency has been in operation three years with no trouble. However, generally, cast iron is limited to pressures of 1000 psi but we would normally continue to recommend and sell feed pumps of this material for pressures below this unless there is indication that cast iron has been unsatisfactory.

4–6-PER CENT CHROME—So far, we have not heard of any failures of this material with some installations having had parts in service up to 50,000 hr, although it has not been used in casings for periods long enough to evaluate it fully. The Detroit Edison Company tests indicate that it is 75 to 100 times as resistant as carbon steel. It casts and machines reasonably well, in fact, just about as well as carbon steel. Its chief disadvantage is that it is difficult to weld. However, it can be welded quite satisfactorily under the proper control, which involves preheating to 800 F, welding hot, and then immediately annealing the casting at 1350 F without allowing it to cool off. If this is not done hard spots will develop around the weld area as well as a tendency to cracking.

2-AND 3-PER CENT CHROME—The Detroit Edison tests included samples of 2- and 3-per cent chrome which performed about as well as 5-per cent chrome. Since these tests were only on one feedwater, one cannot conclude that they are safe to use under all conditions, but they do show that 5-per cent chrome is well above the borderline and provides a good margin of safety.

12–14-PER CENT CHROME—This material has about the same advantages and limitations as 4–6-per cent chrome. It does not cast as well, being subject to hot cracking. It is, however, an excellent material for detail parts, such as shaft sleeves, wearing rings, etc., and we use this material heat treated to 350 Brinell for impeller wearing rings with a higher carbon material heat treated to 500 Brinell for the casing wearing ring.

18–8-PER CENT STAINLESS STEEL—This material on laboratory test seems to be about five times as resistant as 4–6-per cent chrome steel. It has the advantage of being easily cast, is very readily welded and requires no preheat or subsequent annealing. Its principal disadvantage is difficulty in machining, particularly in drilling and tapping.

MATERIALS FOR DETAIL PARTS—For impellers monel has been found a highly satisfactory material, and is resistant to all feedwaters so far encountered. It is readily cast and machined.

Bronze is satisfactory, except for high pH values, although it has the disadvantage of a high coefficient of expansion.

For wearing rings, bushings and shaft sleeves, different hardnesses of stainless steel of the 12–14-per cent chrome grade have been most satisfactory.

Conclusion

Prevention of troubles on new installations seems to lie particularly in the direction of materials which will stand any normal feedwater conditions. It is extremely difficult to control the feedwater, particularly as to pH value and oxygen content so as to definitely assure a favorable feedwater to the pumps. Furthermore, all feedwater control is pointed toward maintaining the best condition at the boilers. For these reasons it is obviously quite impossible for the pump manufacturer to guarantee the pump materials as suitable for the feedwater handled in a particular installation. General practice is to guarantee that the materials will be furnished in accordance with the contract specifications with the user taking the responsibility for the feedwater condition, and for the selection of the materials.

For old installations, in order to avoid trouble with present pumps, the rules outlined above may be helpful; but for new installations the logical method is to purchase pumps constructed of materials which are not susceptible to feedwater attack. The additional cost of such pumps is well justified by the increased reliability and low *maintenance, which will result.*

British and American Generating Station Performance Compared

The February *Journal* of The Institution of Electrical Engineers (Great Britain) carries an abstract of a paper by R. W. Biles entitled "The Grid, Coal and Electricity." This includes a comparison between central station performance in England and in the United States over a period of years, as shown by the following table.

COAL CONSUMPTION PER KWHR GENERATED AT STEAM GENERATING STATIONS

(No Correction Has Been Made for Calorific Value)

Year	Great Britain (Authorized Undertakers Only), Lb/Kwhr	United States (Electric Power Stations), Lb/Kwhr
1899	..	7.05
1907	4.75	..
1913	..	4.02
1920	3.29	3.20
1921	3.07	2.70
1922	2.76	2.50
1923	2.64	2.40
1924	2.50	2.20
1925	2.40	2.10
1926	2.42 (General Strike)	1.95
1927	2.14	1.84
1928	2.03	1.76
1929	1.95	1.69
1930	1.87	1.62
1931	1.80	1.55
1932	1.73	1.50
1933	1.65	1.47
1934	1.58	1.47
1935	1.53	1.46
1936	1.47	1.44
1937	1.43	1.43
1938	1.37	1.41
1939	1.36	1.39
1940	1.42	1.35
1941	1.42	1.34
1942	1.41	1.31
1943	1.39	1.31
1944	1.42	1.33

Commenting on this comparison, the author says, in part: "Taking account only of the weight of fuel and not of its calorific value, in 1937, with 1.43 lb per kwhr, we drew level with the United States and showed a somewhat better overall performance in 1938 and 1939. During the war we fell behind again. . . . In Great Britain the average revenue per kilowatt-hour sold has risen since 1939 from 1.01 *d* to 1.07 *d*, whereas in America it has fallen from 1.08 to 0.82 *d*."

An analysis carried out for the year 1944 showed that 50 per cent of the coal used by electric generating stations in Great Britain was consumed within a radius of 40 miles of the pit, and the average freight paid by these stations was approximately 25 per cent of the cost. On the other hand, the average freight in the United States (using 1938 figures) was more than 50 per cent of the delivery price of the coal. According to Mr. Biles, the average pithead price of coal sold to electric generating stations in Great Britain has increased 235 per cent above 1935 levels.

[There is some question as to whether *the above table represents a true comparison inasmuch as American practice* bases the station fuel rate on net kilowatt production, whereas British practice is generally based on gross kilowatt production. The paper does not indicate whether a correction has been made in the British figures for this difference—EDITOR.]

Two Experimental Gas Turbines Building

Announcement has been made that two experimental gas turbines, one a 4800-hp machine and the other a 5000-kw machine for electric power generation are under construction by the General Electric Company. Shop tests of the first-mentioned unit are scheduled to begin this spring, but the second will not undergo test until next year.

Development of these turbines began before the war but was sidetracked to permit concentration of the Company's facilities on aircraft power plants.

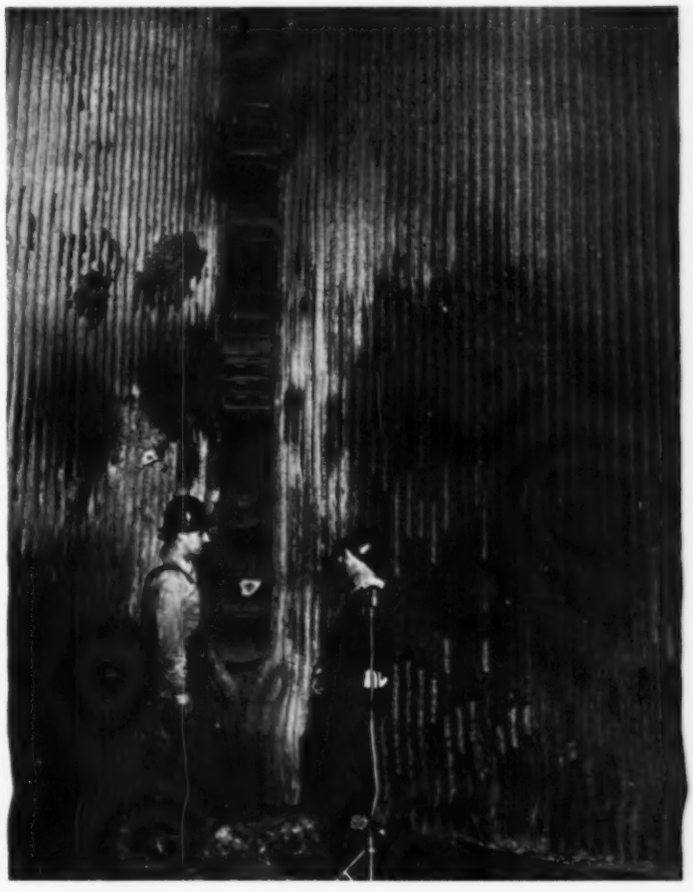
The 4800-hp unit is approximately 19 ft long and will burn Bunker C oil, although work is concurrently being carried on in the use of pulverized coal to permit more diversified use of the gas turbine.

In the 5000-kw unit, which will also be powered with oil, the air will flow through two compressors, an intervening intercooler, a regenerator and then into six combustion chambers. The nominal inlet temperature to the turbine will be 1500 F with the gases expanding first through a two-stage turbine driving the high-pressure compressor at approximately 8700 rpm. The remainder of the expansion occurs through the single-stage low-pressure turbine which drives the low-pressure compressor.

It is understood that the Company will shortly have in operation facilities for large-scale testing of coal combustion for gas turbine applications. Such facilities for testing with fuel oil are already available.

Radio Talk from Boiler Furnace

The Consolidated Edison Company's weekly radio broadcast, "Echoes of New York," on March 20, was featured by a talk by George Hicks, well-known around-the-town reporter, from the furnace of a million-pound-per-hour high-pressure boiler at the Company's Sherman Creek Electric Generating Station. This opportunity was afforded by the unit being out of service for general inspection and overhaul—the first since its installation some four years ago. Mr. Hicks interviewed Alexander Connal, watch engineer at Sherman Creek, who in non-technical language described the immensity of the unit which operates at 1800 pounds steam pressure and consumes 45 tons of coal per hour. However, since both this C-E steam-generating unit and its duplicate now being installed in the same station have already been described in COMBUSTION, its features will not be repeated here.



George Hicks interviewing Alexander Connal in the furnace; *one of the four vertically adjustable burners in background*

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2ND. BITUMINOUS COAL SPECIFICATIONS

Make "Bituminous Coal Specifications for Combustion Equipment" your "first blue print." Tabulate on this form the average quality, characteristics and sizes of at least four coals from different producing districts. These coals should constitute the range of coals to be used for generating low-cost steam during the life of the plant.

From these average data establish the Combustion Equipment Design Factors, using sufficient tolerances to cover normal variations in quality. It is a costly error to purchase new equipment which is inadequate to burn the range of coals economically available.

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3RD. COAL ANALYSIS

Select representative mines in the producing districts shown in the "first blue print," and estimate the probable delivered costs on a B.T.U. basis. For this purpose consider transportation costs, current prices, basic production costs, price trends, and the effect of mine mechanization on future price relationships. Design the plant to use efficiently the coals that have the best competitive future.

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Survey Shows Personality Paramount

When an employer engages a young engineer, he places first importance, not on scholastic record or on engineering experience, but on "personality," according to a report just issued by the Engineers Joint Council through its Committee for Survey of Employer Practice Regarding Engineering Graduates.

This is based on 104 replies to questionnaires mailed to 174 employers of some 40,000 engineers in 19 fields of industry. The question was: "What are the bases on which engineering employees are selected?," and the choices ranged as follows:

1. Personality.
2 and 3. Scholastic record.
4. Engineering experience.
5. Evidence of ability to cooperate with others.
6. Recommendations by qualified persons.
7. Indicated promise for executive development.
8. Standing of college from which candidate was graduated.
9. Salary requested.

In the "write-in" space ten employers added "interviewer's evaluation," and three mentioned "character."

The report summarized the traits of a desirable engineer employee as: "a well-rounded out individuality with good personality, qualified by education and experience to make a good engineer."

In answer to the question as to whether present college training of engineers is satisfactory, 83 per cent voted "yes" and 14 per cent voted "no." The latter listed the following shortcomings, in order:

1. Lack of fundamentals; physical and mathematics.
2. *Inarticulateness in speech and writing.*
3. Lack of education in the humanities.
4. Lack of drafting and design experience.
5. Lack of knowledge of economics and business.
6. Lack of knowledge of operation and *production.*

The report shows that 31 per cent of the total employees of the 104 firms surveyed are engineers, and the median start-salary was $207.

Boiler Inspectors to Meet on Pacific Coast

The 1947 General Meeting of the National Board of Boiler and Pressure Vessel Inspectors will be held at the Biltmore Hotel, Los Angeles, May 5-8. At the conclusion of the meeting the May meeting of the A.S.M.E. Boiler Code Committee will take place, following a hearing on May 7 of the proposed revision of the "Unfired Pressure Vessel Code" a matter in which both groups are interested.

Arrangements have been made for special cars to accommodate members coming from the East.

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APEXIOR

43-1-1

Scrap Iron Salvage

A nation-wide campaign to help alleviate the critical shortage of scrap iron has been launched by the Associated Equipment Distributors which points out that the present shortage threatens to seriously curtail the production of iron and steel and thereby cause a further showing in deliveries of much needed equipment.

A severe drain was made upon the supply of scrap to keep wartime production going at maximum rates; large quantities of iron and steel were lost from the normal chain of return of scrap to steel mills through tremendous shipments overseas, munitions expenditure and ship sinkings; and the scrapping of old model automobiles and trucks, which always furnished one of the largest sources of scrap iron, was greatly reduced because of inability to obtain new models.

Therefore, since the capacity of steel mills is not adequate to meet the present heavy demands for iron and steel, it is urged that wherever possible old construction equipment, parts, pipe, wornout tanks, boilers, etc., be converted into scrap.

A.S.M.E. Announces Schedule for Its 1947 Meetings

Remaining 1947 national meetings of the American Society of Mechanical Engineers have been announced as follows:

Oil and Gas Power 19th National Conference, Cleveland, O., May 21–24.
Aviation Meeting, Los Angeles, Calif., May 26–29.
Wood Industries National Conference, Madison, Wis., June 12–13.
Semi-Annual Meeting, Chicago, Ill., Stevens Hotel, June 16–19.
Applied Mechanics 13th National Conference, in June, time and place not set.
Fall Meeting, Salt Lake City, Utah, Hotel Utah, Sept. 1–4.
Industrial Instruments and Regulators Division, 2nd National Conference, Chicago, time not set.
Petroleum Mechanical Engineering Conference, Houston, Tex., Oct. 6–8.
Fuels Division, joint meeting with the Coal Division of the American Institute of Mining and Metallurgical Engineers, Cincinnati, O., time not set.
Annual Meeting, New York City or Atlantic City, N. J., Dec. 2–5.

N.D.H.A. Changes Date of Meeting

The 38th Annual Meeting of the National District Heating Association originally scheduled for June 16–19 at the Ambassador Hotel, Atlantic City, will be held on June 24–27 at the Chalfonte-Haddon Hall Hotel, Atlantic City. The change in time and place was made necessary in order to secure adequate accommodations for the expected attendance.

Peak Loads Remain High

Figures compiled by the Federal Power Commission showed the aggregate of major electric utility system peak loads for February to have totaled 42,036,000 kw. This was the highest February load experienced to date and was 16.7 per cent greater than February of last year. It exceeded the wartime maximum of 38,252,630 kw reached in January 1945 and approached the record high of 43,173,808 in December 1946.

Corresponding energy requirements for February amounted to 19,247,000,000 kwhr which represented an average gain of 20.6 per cent over that of February 1946. The greatest per cent gain in demand was in the Northwest and that for peaks in the east central states.

E.E.I. to Meet in Atlantic City

Plans have been announced covering the 15th Annual Meeting of the Edison Electric Institute at Atlantic City, N. J., beginning Monday, June 2, and continuing through Thursday, June 5. All general sessions, business meetings and major events will be held at the Convention Hall and other meetings at various Atlantic City hotels.

The general theme of the meeting is "Looking Ahead in This Industry," and such subjects as public relations, industrial relations, personnel practices, training of junior executives, leadership and relation of the electrical industry to the national economy, will occupy important parts of the program. In addition to talks be a number of well-known utility executives, there will be addresses by several industrial leaders.

A feature of the Thursday luncheon will be a talk by General Wade Hays, president of Edmundson's Electricity Corporation, London, on "Pitfalls in the British System."

Personals

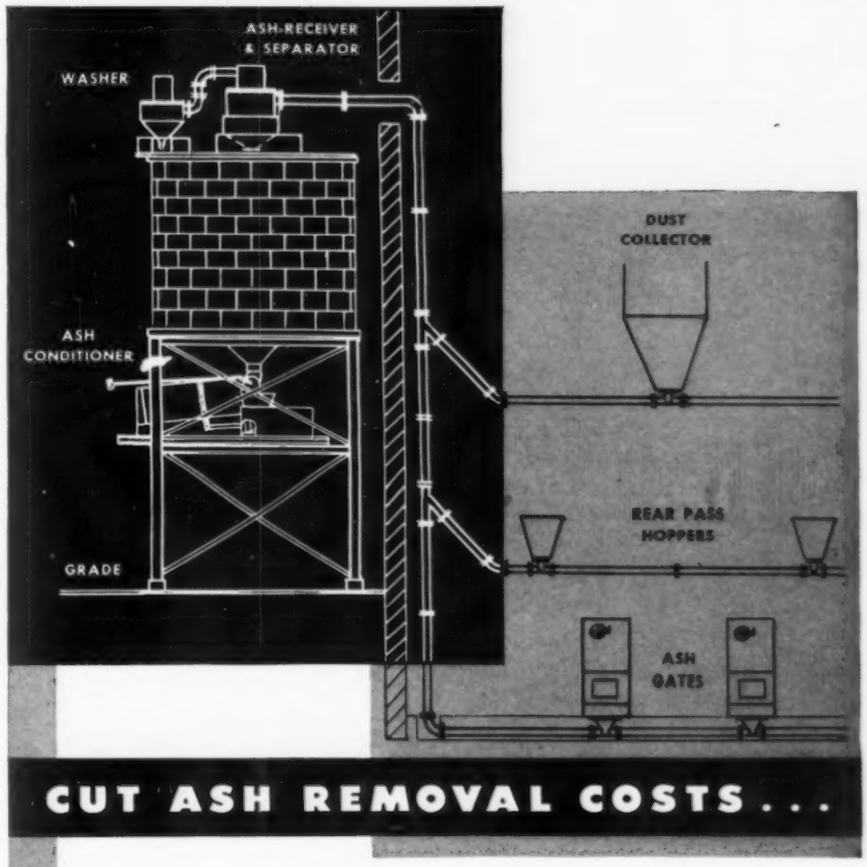
Stephen M. Davis has been appointed to the staff of Battelle Memorial Institute, Columbus, Ohio, where he will be engaged in research on fuels technology.

G. A. Porter has been made assistant chief engineer of power plants for The Detroit Edison Company. He succeeds Walter D. Drysdale who retired after 42 yr of service.

P. S. Dickey, former chief engineer, and **H. M. Hammond**, former general sales manager, of Bailey Meter Company have been elected vice presidents of that company.

W. H. Pugsley has been appointed vice president in charge of field research for The Hays Corporation and **S. M. Rudolph** vice president in charge of sales.

R. R. Donaldson has been appointed chief engineer of Hagen Corporation, Pittsburgh, taking over the duties of T. A. Peebles who retired several months ago.



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Books

1—Steam Power Plant Auxiliaries and Accessories (2nd Edition)

By Terrell Croft

Revised by D. J. Duffin

583 pages Price $5.00

This is a second edition, revised by D. J. Duffin, of a book by Terrell Croft which is intended to serve as a practical manual for quick help in selecting, installing, operating and maintaining power plant auxiliaries. The book, which is profusely illustrated, has been entirely revised and reset to conform to the many changes that have taken place since the first writing, although the general character and scope of the original have been preserved.

Evaporators, deaerators, air preheaters, piping maintenance, certain types of pumps, specific speed, cavitation, motor applications and a few other topics are discussed for the first time in this edition. The present tendency toward higher pressures and temperatures and its effect upon plant design and operation have been considered. An appendix of useful tables and data has also been added.

2—Specifications for Steel Piping Materials

307 pages Price $3.00

In addition to all A.S.T.M. specifications covering steel piping and tubing, the December 1946 compilation of A.S.T.M. Specifications for Steel Piping Materials includes requirements on a number of other materials which are used in piping installations, such as castings, forgings, bolting materials and nuts.

The book includes 14 specifications covering various types of pipe ranging from ordinary carbon pipe for a variety of uses to high-alloyed steels for high-temperature and high-pressure service. Thirteen specifications cover various types of boiler, superheater and miscellaneous tubes, including four standards on stainless tubing. Three specifications cover still tubes and a similar number pertain to heat-exchanger and condenser tubes. Five standards cover castings used in pipe installations, including valves, flanges and fittings, and there are four specifications covering forgings and welding fittings. Three standards cover carbon and alloy-steel bolting.

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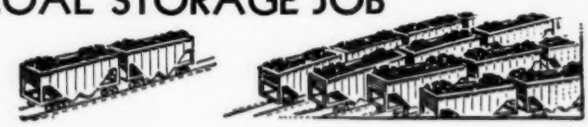

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3—Thermodynamics

By G. A. Hawkins

436 pages $8^1/_2 \times 5^3/_4$ Price $4.50

Drawing on his broad background in teaching at Purdue University, as well as in the practical application of thermodynamics in engineering, Professor Hawkins has turned out an excellent text. Emphasis has been placed on those concepts and applications that his experience has shown to be of most value to the engineer in the practice of his profession.

By adopting the current usage of solved problems to illustrate the points under discussion, clarity is imparted to both students and to engineers renewing their familiarity with the subject. This value of the book is further enhanced by a comprehensive and well-arranged index and by the inclusion of the fundamentals of heat transmission.

4—Steam Power Stations Third Edition

By G. A. Gaffert

613 pages 6×9 Price $5.50

The first edition of this book appeared in 1937 and the second in 1940. The present edition brings the reader up to date on the latest developments in the steam plant field.

The text is a concise and practical book on steam power stations which is confined to the mechanical engineering features. It deals with the construction, performance characteristics and integration of the major and minor items of plant equipment. The introduction includes an historical background of the utilization of power and the growth of the power industry. Successive chapters dealing with the various equipment items begin with a discussion of fundamentals followed by descriptions of various modern types, together with performance characteristic calculations, and end with a "problems" section.

The text is profusely illustrated with diagrams and cuts of modern types of equipment, and many graphs and charts are included. The numerous typical computations should be of value in grasping the problems of plant design. These include heater-extraction-cycle computations, combustion calculations and boiler heat balance, circulation, heat transfer in economizers and air heaters, and high-pressure extraction-cycle computations.

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